AMATEUR WORK

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A HOT AIR ENGINE.

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It is the purpose of this article to describe a small caloric or hot-air engine, which may be used to drive a dynamo, small lathe, sewing machine, or for any similar purpose not requiring more than one-eighth horsepower. As such engines are not in very common use a few words as to their efficiency, their limitations, and the general principles upon which they operate, may be in order. A hot-air engine is much less efficient as a producer of power than a gas engine, and must be several times larger to produce the same amount of power. It will compare fairly well with a small steam engine in power produced for a given amount of fuel, but has the advantage of great simplicity and few moving parts. There are no valves, ignition devices, batteries, etc., and no boiler, gauges, pumps, etc., to look

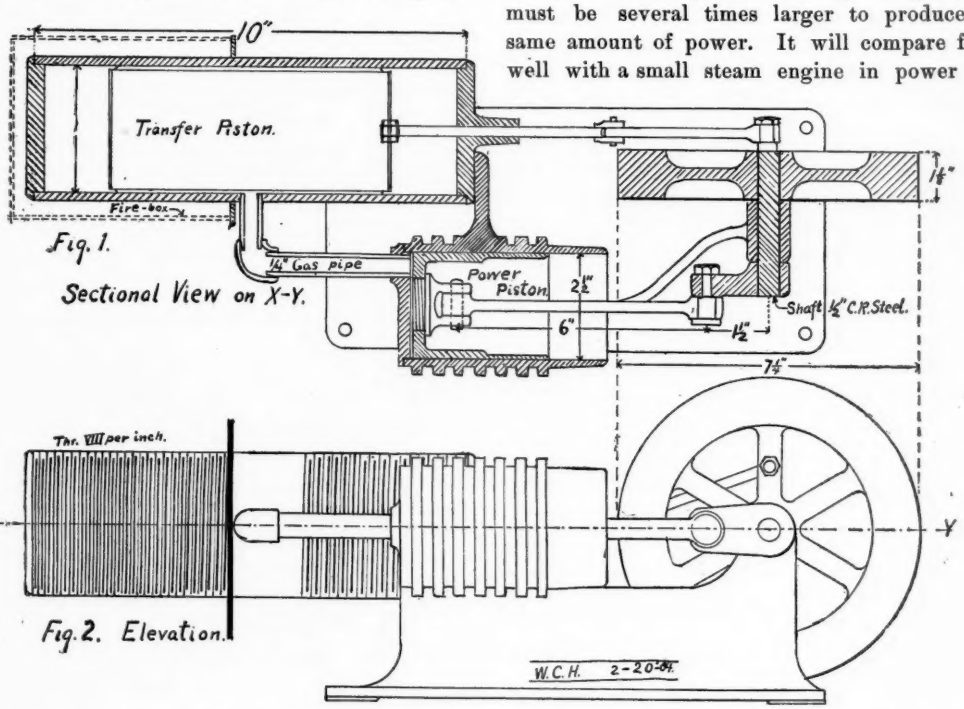


Fig. 1. Sectional View on X-Y.

Fig. 2. Elevation.

after, and nothing which could possibly cause danger. Such an engine is not, however, adapted to any use requiring great power, or absolute steadiness under variations of load.

It is well known that all substances expand more or less when heated, and contract again when cooled. Air can be expanded to many times its original volume if slightly heated. This fact is made useful in the caloric engine. A small quantity of air, confined in an iron cylinder, is quickly heated, and as it expands is made to push a piston in a connected cylinder. The same air is then cooled, and allows the piston to return, the process being then repeated. This alternate heating and cooling may be accomplished 100 to 150 times per minute, giving as many revolutions of the engine. The way in which this is done may be understood by reference to Fig. 1. The larger cylinder, shown in section at the top, is for heating and cooling the air. All but the middle portion of this cylinder is deeply threaded to give greater radiating and heat absorbing surface. The left hand end is enclosed in a fire-box (not shown) and a suitable burner placed beneath. A gas, oil, or alcohol burner may be used. The right hand end is for cooling, and may be provided with a small fan-wheel driven by the engine to increase the air circulation, and thus cool the air inside more quickly. In the drawing the loose fitting transfer piston operated by a connecting rod from a crank-pin on the fly-wheel, is about at the middle of its stroke to the right. This will displace the air from that end, forcing it to the hot, left hand end of the cylinder. As it expands it pushes its ways through the pipe leading to the power cylinder and drives the piston outward. At the end of the out stroke, the transfer piston will have moved so as to send most of the air to the right hand end of the cylinder, where it cools and allows the piston to return. The transfer crank is set 90° ahead of the power crank in order to give time for heating and cooling.

The construction of the engine will now be taken up. The bed-plate, power cylinder and bearing pedestal are cast in one piece, with the cylinder cored straight through for convenience in machining. The cylinder has a bracket cast on the back for attaching the heating cylinder. The construction might be somewhat easier if the cylinder were made of tubing, but cast iron is the only really suitable material for such parts. First, file or plane off the feet on bottom of bed plate so that it will stand firm. Then bolt casting to tool carriage of an engine lathe and bore out cylinder with a boring-bar and fly cutter. The last cut should finish as smooth as possible to a diameter of 2 $\frac{1}{2}$″. The ends of cylinder should also be trued up by setting the cutter out and grinding it so that it will cut on both sides. Next locate centre of bearing on a level with centre of cylinder, and drill to $\frac{3}{64}\frac{1}{4}$″ diameter, and ream to $\frac{1}{2}$″. Face off ends of bearings to lengths of 1 $\frac{1}{8}$″ with a counterbore in lathe or drill press. To finish cylinder, make a lead lap, by casting a cylinder of lead about 4″ long, and 2 $\frac{5}{8}$″ diameter around and near one end of a piece of round iron or steel about 12″ in length and provided with suitable centres. Turn lap down to a trifle less than 2 $\frac{1}{2}$″ diameter. Put some fine emery powder on a board, or better, a flat piece of iron. Smear lap with oil and roll in the emery, pressing hard enough to embed emery in the lead. Slip cylinder on the lap, put lap in the lathe, and grind inside of cylinder smooth and true, using the highest speed of lathe, and oiling the lap often enough to keep from running dry. This will produce a cylinder that is truly round and highly polished. If the piston be finished in a similar way and made a good fit, there will be no need of packing rings to keep piston air-tight. The cylinder head is turned off with a shoulder making a drive fit with end of cylinder. The hole is drilled and tapped with a $\frac{1}{4}$″ pipe tap. Head may be threaded and screwed into cylinder if desired. If not screwed in, it should be secured by four pins driven into holes drilled through cylinder walls into head. In either case the joint should be made tight with red lead.

The piston should be cast with a 1″ hole cored through the back end. Hold in a chuck by this end and bore out inside enough to clean up. Also face up bottom around hole for wrist-pin fork to screw against. Reverse piston and drive on a piece of iron held in chuck and turned to fit. Turn off outside to 2 $\frac{1}{2}$″ diameter, face off end, bore and thread hole 1 $\frac{1}{4}$″ diameter by 20 threads. The outside of cylinder should be finished very smooth and true with a dead smooth file and emery cloth. It may be left a trifle tight

fit for the cylinder and the two ground together with flour emery and oil. The wrist-pin fork, which should be a brass casting, may be held in a four-jaw chuck, the end faced off and shoulder turned down and threaded to fit hole in piston. Also drill a hole in end, taking care not to go through, and tap out $\frac{1}{4}''$ x 20 threads. Then take out of chuck and screw to an angle-plate, centering by turned base and height of boss, and drill for $\frac{5}{16}''$ wrist pin. The wrist pin may be made of cold rolled steel cut off to the right length, and secured by drilling and pinning through one boss after connecting rod is in place. The sides of fork may be faced off in lathe by mounting on back of face plate, but in same position as for drilling wrist-pin hole. The connecting rod should be a brass or bronze casting, but it may be made of bar steel $\frac{3}{8}''$ x $\frac{5}{8}''$. Lay out centres in bosses at each end 6″ apart. Drill with No. 10 drill and tap $\frac{1}{4}''$ x 20 thread then fasten to face plate by machine screws through slots. The bosses may now be turned off on one side, the rod turned over and faced off on the other side to $\frac{3}{8}''$ thick, to fit fork. Then enlarge holes to $\frac{3}{8}''$ and $\frac{5}{16}''$ respectively for crank-pin and wrist-pin. The balance wheel should be drilled and reamed to $\frac{1}{2}''$, then mounted on an arbor and the rim turned on edge and both faces; diameter, 7 $\frac{1}{4}''$, face, 1″. A wheel suitable for this purpose may often be found in the scrap iron pile at a junk dealer's or taken from some old machine. The exact dimensions are not essential, but it should be fairly heavy and run true. If the builder makes his own patterns, it may be found easier to make a solid webbed wheel rather than one with spokes. Both ends of hub should be turned true while wheel is on arbor. The crank is a small iron casting which should be drilled to $\frac{1}{2}''$ in the shaft end. The crank pin end may then be drilled and tapped with $\frac{5}{16}''$ standard thread, just 1 $\frac{1}{2}''$ from centre of shaft hole. Care should be taken to get the holes parallel. The shaft may be made of cold rolled steel and will need no turning. Crank pin may be turned from the same stock. Balance wheel may be secured to shaft by a set screw, and the crank by a taper pin driven through both. This method of fastening would not do in a gas-engine where there are severe shocks to take care of, but the motion of a caloric engine is very smooth and easy.

The heating cylinder and transfer piston may now be taken up. The cylinder is made of a piece of 3″ iron pipe 10″ long. It should be threaded for four inches on each end. The threading may be done by the steam fitter who supplies the pipe, or it can be done in a lathe by mounting on a rough arbor. A piece of hard wood will do for an arbor, if supplied with iron centres. It should be made with the large part a little shorter than the pipe so that the ends may be trued up and bored out inside for a short distance. The inside of the ends may be threaded so that the heads can be screwed in if desired, but this is not necessary. The back cylinder head is simply turned up, with a shoulder making a drive fit with the end of cylinder, or threaded to fit as the case may be. The front head is the same, except that it has a hole drilled and reamed for $\frac{3}{16}''$ piston rod. Both heads are cast from one pattern, the central boss on the back head being used as a chuck piece and then cut off. If the heads are not screwed in they should be fastened by drilling and pinning. In either case, the joints are to be made tight with red lead. The transfer piston may be made of 18 or 20 gauge sheet iron seamed together at the joints. This is a tinsmith's job and should be left to him. The heads of piston should be of heavier iron. The piston rod should be secured to the front head, and three strips of sawed brass about $\frac{1}{16}''$ thick and $\frac{3}{16}''$ wide, should be riveted along the sides before piston is put together.

These are for the piston to slide upon inside cylinder. Diameter of transfer piston is scant 2 $\frac{7}{8}''$. The joints in the piston need not be particularly tight, and one or more small holes should be drilled through the side to prevent air pressure on inside when heated. The piston rod is a piece of cold rolled steel $\frac{3}{16}''$ diameter and 5 $\frac{1}{4}''$ long, threaded at each end. The outer end is screwed into a small knuckle joint, which may be made of sawed brass. The connecting rod is also made of sawed brass, $\frac{1}{8}''$ x $\frac{5}{16}''$ and is 4″ from centre to centre of holes. The crank pin for transfer piston is turned up from soft steel, driven into a hole in one spoke of fly wheel, 1 $\frac{1}{2}''$ from centre, and riveted over on back. The outer end may be drilled for a small split pin, and the connecting rod held on by a washer under the pin.

This completes the work on the moving parts of the engine. The bracket on side of power cylinder should now be drilled, the holes spotted through on to the front head of heating cylinder. These holes should then be drilled and tapped for fastening on the cylinder. A hole should now be drilled in the side of the cylinder and tapped for $\frac{1}{4}''$ pipe. A short nipple is screwed into this, and an elbow and another short piece attached to connect with power cylinder. After the piping is made up, the screws fastening to the power cylinder may be put in. All that now remains is to provide a casing or fire-box on the hot end of the large cylinder. The foundation of this is a ring of heavy sheet iron cut out to fit tightly around the cylinder. The shell of the fire box is made of two layers of sheet iron with asbestos between. It should be open at the bottom for the burner and have a suitable flue at the top through which the products of combustion may escape. As the exact shape of the fire box will depend on the burner, this is left to the builder. In any case there should be a space at the sides and end of the cylinder, to give all possible heating surface. The description of a kerosene burner for this engine will be given in a future issue

MICROSCOPY FOR AMATEURS.

S. E. Dowdy. M. P. S.

V. Testing the High Power Lens.

Now, with regard to the question of the aperture of the lens, suppose, for example's sake, we were observing the minute markings on a diatom valve with a narrow apertured lens of good workmanship. If the diatom was a suitable one, we should probably see a series of fine lines close together, these becoming more apparent if oblique illumination is used. If a wide apertured lens was now substituted, though of exactly the same magnifying power, it is very probable that these lines would be shown as what they really are — vis. a series of beads or dots, thus affording an example of the value of aperture in an objective. Supposing we now replace our narrow-angled lens and tried the effect of various eyepieces on the image yielded by it, we should find that when we got to eyepieces magnifying more than about ten diameters the image would greatly deteriorate in quality and break down, as it is termed. On the same object, however, the wide-angled lens would work with much more powerful eyepieces without showing much falling off. This is, of course, explained by the theory on which images are formed in compound microscope. The primary image formed by the objective is magnified by the eyepiece; any imperfection is, therefore, shown in proportion to the magnifying power of the eyepiece employed. This is the reason why powerful eyepieces are of little use to the student, because his lenses, owing to their want of aperture, would break down, or else not admit sufficient light with such eyepieces. The real value of aperture, therefore, is that it imparts brilliancy of image, better definition and resolving power to a lens. It should not, however, be forgotten that increased aperture means vastly increased skill to impart the necessary corrections for the elimination of spherical and chromatic aberration; so that, unless the workmanship be really good, the increase in aperture may be more than counter-balanced by the presence to a certain extent of these defects.

If possible, it would be a good plan for the student to beg the loan of a large-apertured $\frac{1}{4}''$ lens, and try it under these conditions against his own *comparatively* narrow-apertured objective of the same focal length. I say "comparatively narrow-apertured," because, as before mentioned, students' lenses are now mostly made with wider angles than they used to be, owing to the recognition of the fact that increase of aperture, with good workmanship, means increase of resolving power and improvement in definition. Unfortunately for those of limited means, increase of

aperture involves a big increase in price, owing to the skill and care required to eliminate spherical and chromatic aberration under such conditions. If possible, though, it is a good plan to pay the extra money asked for, and substitute a fairly wide angled 1″ lens for the lower apertured one likely to be supplied with a student's stand. The increased cost will be fully repaid, because the wide angled objective, if by a good maker, will admit more light, define better, and, what is an important point to anyone not provided with a large selection of lenses, will stand much deeper eyepiecing. It may have a shorter working distance; but that is not a very grave defect, providing the focal length is anything over ½″. A low-power lens can be satisfactorily used, even by the beginner, except perhaps for dissecting purposes.

I should not advise the student, however, even if he can afford it, to purchase a large-apertured high-power dry lens, because such an objective, though yielding finer results in experienced hands, is not an easy thing for the beginner to manipulate. For one thing, a slight alteration in thickness of cover or length of body-tube will impair the image shown by it; but the most serious drawback would be that its working distance would be extremely short, perhaps so much so that only the thinnest of cover-glasses could be used over objects viewed through it.

The term "dry lenses" has been used several times in explaining the manipulation of the ordinary objectives the student is likely to require. The adjective is used to distinguish such lenses from those which have their fronts immersed in a liquid, such as oil or water, and which are therefore known as "immersion objectives." It must suffice to just mention their existence, as unless the student is taking up the study of bacteriology, he will not require a lens of this kind. Without therefore, entering into an explanation of the principle on which this type of lens construction is based, which would involve the introduction of such terms as refraction and dispersion, and imply a previous knowledge of optics on the reader's part for a proper understanding, it will be, perhaps, sufficient to say that immersion lenses have a greater working distance than dry ones for the same aperture, and are also less sensitive to thickness of cover-glass. Of this type of lens, $\frac{1}{12}$″ oil immersion is the one most frequently used in biological and bacteriological work. Such a lens having an aperture of 1.25 can be obtained for $25 upwards, so it will be seen that an objective alone may cost much more than a complete students' microscope. Immersion lenses are not difficult to use, it being necessary merely to put a drop of either cedar oil or water, as the case may be, on the cover-glass surmounting the object. The objective is then lowered by the coarse adjustment until its front lens touches this liquid, when focussing is completed, without removing the eye from the body-tube, by means of the fine adjustment. After use the lens-front should be carefully wiped with absorbent cotton-wool before replacing it in its case. Enormous magnifying powers up to seven thousand diameters may be obtained by the use of such lenses and suitable eyepieces; but such magnifications are seldom required (except in bacteriology and similiar work) and cannot always be relied upon, like the images obtained with a lower-power lens.

To test an oil immersion or water immersion lens it should be tried upon stained bacteria, or suitable diatoms, but as such a lens does not comprise part of an ordinary students' outfit, we can leave the matter until the observer has sufficient microscopical experience to suggest the best method for such an objective. It will then be time enough for thinking of purchasing such an article. We have now shown how the lenses supplied with the microscope, or purchased subsequently, may be tested, and by the time the student has done this, he should have arrived at the best method of handling the instrument for ordinary working purposes. A few words, as to certain precautions that should be used in actual working may not be amiss at this point.

It is often thought that work with the microscope and artificial illumination ruins the eyesight. Such is not the case, if care be taken to only use sufficient light to clearly make out the details of an object, to only work when in good physical condition, and only so long as no strain is felt on the eyes. The yellow glare from the lamp employed should be toned by passing it through blue glass, and this can be done by either

using a blue glass chimney, or by placing a disc of the glass in the stop-carrier of the substage condenser. Powerful eyepieces should be avoided as much as possible, and only sufficient power used to clearly make out the detail looked at. It is also a good plan to get into the habit of using the right and left eye alternately, and to keep the one open whilst the other is at the eyepiece. This may seem difficult at first, but is easily acquired by a little practice. It has been noticed that whilst the eyes of one accustomed to use the microscope to a great extent may be rendered less susceptible to intensity of light, they become much more sensitive with regard to perceiving fine detail, which is only what might be expected. With regard to using both eyes, the beginner may be tempted to say. "Why not purchase a binocular microscope, and always use both eyes? Unfortunately, however, binoculars cannot be used to much advantage except with low-power objectives, owing to loss of sight from the prisms and other optical reasons. Some of the best class of students' stands can now be obtained fitted with binocular body-tubes, but the novice is not advised to purchase one for reasons too numerous to mention to be gone into here, though, if he likes to obtain one in which the monocular body can be easily substituted, there will be occasions on which it can, as a binocular, be used to advantage.

Having described the instrument and its lenses, a word or two with regard to the use and purchase of the various adjuncts to it, known as accessories, may be said. The student will not be long in finding that to successfully carry out many operations with the microscope he must employ one or other of these adjuncts. For instance, if he wishes to look at an opaque object, *as such*, he must have recourse to the use of what is known as a "bull's eye condenser," or if he wishes to rapidly change his lenses he must, unless he unscrews them every time, employ a nose piece, and so on.

Accessories can always be purchased separately or picked up second-hand, and such should include, besides the bull's eye condensers and nose piece just mentioned, a live box, micrometers, a cheap form of camera lucida, and some form of polarising apparatus. For mounting objects a pair of forceps, scissors, watchglasses, slides, covers, and the usual paraphernalia will be requisite, besides a good form of hand lens, either the ordinary single lenses in frames or, preferably a compound lens, such as those termed aplanatic, etc., by the makers.

Space will not allow of more than the briefest indication of the use of each of the more generally required accessories, and the beginner is advised to first procure as good a textbook on microscopes as he can afford, and to carefully make out the specific use and scope of each article before purchasing it; otherwise he may obtain his experience in a not unusual fashion by paying rather dearly for it. I would, however, warn novices from buying old and out-of-date works on the microscope, as in the light of recent improvements and discoveries they are only misleading, and apt to create erroneous impressions. For the benefit of those quite ignorant of the use of the microscope and its accessories I might briefly describe those adjuncts which I have mentioned as being required to complete the student's microscope outfit.

The Bull's-Eye Condenser. — This useful piece of apparatus consists of a plano-convex lens, mounted in a sliding arm attached to a pillar so that any required position of the lens may be attained with a little manipulation. The specific purpose of this accessory is to illuminate opaque objects by concentrating and bringing to a focus light from the lamp upon these specimens, which could not from their opacity be viewed by transmitted light from the mirror. It can only be satisfactorily used with low power objectives, so that its usefulness is to a certain extent restricted, still, it is a useful accessory for all that. Bull's-eye condensers vary in price from about $2.00 upwards, according to size of lens and method of mounting, but a small one will answer the beginner's requirements.

The Nose Piece. — This is one of the most useful and time saving devices the worker with the microscope can possess. It consists of a peculiar shaped revolving double collar, rather difficult to describe, but very simple in construction and working. By its means objectives of varying focal length can be employed and rapidly changed without unscrewing or screwing in the lenses each time into the body-tube of the instrument.

Both time in working and wear and tear on the objective screw threads are saved, thus constituting this little addition to the outfit a most welcome one. Nose-pieces are made in either brass or aluminum to carry two, three, or sometimes four objectives. The student is advised, however, to obtain one to carry two only, because all the weight in some forms of instrument comes upon the fine adjustment, and a quadruple nose-piece loaded with four objectives is no light weight for a delicate mechanism and stand. The price of this necessary ranges from $2.50 upwards, for simple as it is in appearance, it requires to be very carefully made to insure accuracy in centreing the lenses. One of its chief uses to the student would be in finding objects when high magnifying powers were being employed. For instance in picking out a certain diatom on a mixed slide, a low-power lens would be used, the diatom being put into the centre of its field; the nose piece would then be rotated to bring the high-power lens to bear upon it, when, on focussing, the diatom should appear in the centre of the field of the higher-power lens.

A Live Box consists of a raised ring of brass mounted in a small brass plate, and having a circular glass resting upon it. Over this ring another is made to slide, this upper ring also encircling a glass cover. Any object placed on the lower glass, and the cover put on, is therefore in a sort of box or cage. This piece of apparatus, costing anywhere from 75 cents upwards to $2.50 or thereabouts, is principally used in observing pond life, but can be put to a variety of purposes. It can, however, be dispensed with, as an ordinary shallow cell can be made to answer fairly well in its place.

Micrometers consist of glass slides or circles, ruled in minute parts of an inch, or in millimeters. They are, of course, for measuring specimens viewed under the microscope, and are also of use in determining magnifying power. The methods of using them can be seen in any good textbook, and they are useful little appliances. Two would be required if the student wished to determine visually the dimensions of objects, one ruled and mounted as an ordinary 3″ x 1″ slide, the other as a circle to drop into the eyepiece. The usual cost is $1.00 each for those ruled to the $\frac{1}{100}$″ and $\frac{1}{1000}$″.

A Camera Lucida for the microscope is an appliance for making accurate drawings of objects. The simplest form, and the one most suitable for the student is what is called Beale's neutral tint reflector, costing about $1.50. There is a certain knack in using both forms of camera lucida; but when once picked up it is not readily forgotten, and accurate drawings, or rather tracings to scale, may be made by onyone.

Photography is, however, rapidly displacing this method of recording observations, though, of course, photography is not always applicable.

English Mechanic.

LANTERN SLIDE MAKING.

R. G. HARRIS.

II. Slides by Reduction on Commerical Plates.

In the previous chapter a very elementary decription was given of the production of a lantern slide with the aid of a printing frame. The method given would scarcely satisfy any but a beginner anxious to produce a lantern slide without venturing too far into the intricacies of the subject. Complications and refinements are sure to attract the worker before long, the printing frame will be discarded for the camera, and the black colors gradually give way to warmer ones. To anticipate the desires of the worker, it will be desirable to devote the present chapter to the description of some arrangement for producing lantern slides by reduction with a camera, involving the use of both artificial light and daylight.

It was remarked earlier in these chapters that for any negative larger than quarter-plate it was essential to resort to camera reduction for producing lantern slides if the whole of the subject

was wanted in the slide. The opinion may also be hazarded that as the lantern slide worker becomes more competent he will incline more and more towards camera work as a means of slide making. Some processes for making lantern slides, though giving most excellent results, are too slow to permit of exposures in the camera, and one is compelled to reserve them exclusively for contact use, but in case of a plate like the lantern plate of commerce, which is available either for contact or reduction, the camera will be found to be the most satisfactory means of obtaining a lantern slide. Even in the case of quarter-plates, which have been taken with a lens of fairly long focus, it is seldom that the slide would not have been better for the inclusion of the whole of the subject.

The camera for use in making slides by reduction may be the ordinary field camera if it is of the "stand" camera pattern, but where lantern slide work is followed systematically it is most desirable to have a camera relagated to the work of lantern-slide production. The arrangement which is used by the writer is simple in construction, and does all that is required in making lantern slides by daylight reduction. It consists of a baseboard about four ft. long and one ft. wide; between two parallel guides running the whole length of this baseboard slides a block of wood the same size as the base of the camera, and having a ledge at either end to hold the camera firmly. A negative holder, with carriers for various sizes of negatives, slides at the other end of the baseboard, and the whole enables lantern slides to be obtained from negatives 15″ x 12″ down to 4 ¼ x 3 ¼. The camera used on the baseboard is a square half plate, but, of course, any camera can be adjusted for use in a similar manner. A very convenient instrument is one of the square sliding-body cameras made for wet plate work, which might be bought for a small sum. If a camera of this description is firmly affixed to the block sliding between the parallel guides, it makes a most efficient camera for lantern slide reduction.

The lens should not be of very long focus, or the exposures will be inconveniently protracted. Four and a half inches is a convenient focal length, and although a single landscape lens is permissible, it is better to use a lens of rapid rectilinear form to avoid any possibility of distortion. The whole arrangement is inclined so as to command a clear view of the sky. If it is possible to exercise any choice, a northern aspect should be selected, as then no trouble is experienced from sunlight striking the negative. Should a north or northeastern aspect be unobtainable, or should such objects as trees and chimneys project into the field of view, it is convenient to cover that part of the window used with one or two thicknesses of tissue paper, or, which is even better, a single thickness of white demy paper. Two rods are used connecting the camera and negative holder; these are simply loose rods laid across to bear the focussing cloth, which is thrown over previous to exposure, to make a dark chamber between the lens and negative, a precaution that prevents any diffused light operating on the negative from the rear. Using the arrangement for daylight exposures, with a four and a half inch lens and $\frac{1}{16}$″ stop, the exposures with ordinary lantern plates will be about twenty seconds for black colors and up to three minutes for warm colors, the negative reduced being a half plate, and the light outside good, diffused spring light.

It will be impossible here to go into the question of conjugate foci, so intimately associated with all matters of enlarging and reduction. The better plan for the beginner is to arrive at the correct distances that are necessary between the lens and plate on the one hand, and between the lens and negative on the other, by a system of trial and error, remembering that the greater the reduction the further the negative has to be from the lens, and the less camera extension needed. Once the correct distances have been found, marks made on the baseboard for the positions of the camera and negative holder will enable them to be speedily adjusted on all subsequent occasions. As a rough guide for preliminary trials, the accompying table may be of assistance to the beginner.

Reduction in the camera by the aid of artificial light is quite easily accomplished in the absence of daylight, and the majority of lantern slide workers will find artificial light more convenient, as work can be carried on in the evening. The apparatus is that used in daylight reduction so

far as the baseboard and camera are concerned, but is is, for convenience sake, used horozontally upon a work bench. Two Welsbach burners constitute the source of illumination, and the light is diffused by passing through two thicknesses of tracing paper placed over the negative holder. The burners require adjusting at a sufficient distance from the tracing paper to give even illumination, and to this end they are fixed on a sliding stand.

Focus of lens	Half-plate Negative to 3 ¼ x 3 ¼	Whole Plate (8 ½ x 6 ½ to 3 ¼ x 3 ¼
	14 inches negative to lens	21 inches negative from lens
3 ½ inches	4 ½ in. focussing screen to lens	4 ,, screen ,, ,,
	18 in. negative from lens	27 ,, negative ,, ,,
4 ½ inches	6 in. screen from lens	5 ½ ,, screen ,, ,,
	20 in. negative from lens	30 ,, negative ,, ,,
5 inches	6 ½ in. screen from lens	6 ,, screen ,, ,,
	24 in. negative from lens	36 ,, negative ,, ,,
6 inches	8 in. screen from lens	7 ,, screen ,, ,,

The lens for use with artificial light should have as short a focus as possible to secure the maximum amount of illumination. A 3 ⅛″ rectilinear is very convenient if of good quality, so as not to require stopping down before definition can be obtained. In place of the Welsbach burners an arrangement may be substituted by burning magnesium ribbon, or a flash lamp. The burners, however, are by far the most reliable illuminant. Magnesium ribbon is most convenient for contact exposures with very slow plates, but for reducing purposes its use is attended with some degree of uncertainty.

The simplest way of camera reduction, when the negatives are all of one size, is to use a "fixed focus" camera. A rectangular box of the size of the negative to be reduced has provision made for holding the negative at one end. At the opposite end of the box is a frame with 3 ¼″ x 4″ aperture, into which a lantern plate is placed and held in position by a spring, a light tight lid fitting on the end of the box. The lens is fixed near the middle of the box in a rigid frame, in the position to focus accurately upon the lantern plate. All that is necessary is to place the negative in position at one end of the box and a lantern plate at the other, to cover up both ends until the apparatus has been illuminated, and then to expose by removing the cover of the negative.

It will be seen that this method of work has very serious limitations. Should it be necessary to enlarge slightly the image so as to exclude from reproduction some unessential portion the camera fails utterly. Nor is it possible to use it for any other size than for which it has been made. Printing by "contact" necessitates little apparatus beyond the ordinary printing frame as used for paper prints. Ingenuity has been expended in devising printing frames specially for use in lantern slide work. They are convenient when a slide is printed by contact from some portion of a negative very much larger than the lantern plate. But the slide maker may be contented with an ordinary printing frame, merely putting underneath the negative a piece of plain glass the size of the frame for the negative to rest upon. By so doing, no danger of fracturing the negative from the unequal pressure of the lantern plate may be feared.

Photography.

In Algeria, steps are now being taken for the production on a large scale of natural soap from the tree known as *Sapindus utilis*. This tree, which has long been known in Japan, China, and India, produces a fruit which, when ripe, is about the size of a chestnut, smooth and plump. The color varies from yellowish-green to brown, and the inside is of a dark color and contains an oily kernel. If carefully chosen, a cutting from this tree in the course of two years reaches the height of 6 ft.

It does not, however, reach maturity until its sixth year, when it bears from 25 to 100 kilogrammes of fruit, which are ready for picking towards the end of autumn. The methods of treating the fruit to obtain from it its saponaceous properties are varied, water or alchohol being generally used.

PATTERN MAKING FOR AMATEURS.

F. W. PUTNAM.

I. Somtehing about Suitable Wood.

This series of articles on pattern making will be so written as to be of value to those amateurs whose stock of tools is not large, and to those whose practical experience with model making is very limited. It is surprising to see the amount of ingenuity displayed by some model makers in attempting to supply a lack of pattern making ability. If the same amount of time and patience had been properly directed, the model maker would have been able to make patterns, not for one model alone, but for about anything else he wished to make.

It is not pleasant, after much time and labor have been expended upon the wooden model, to hear the decision of the founder that it is quite impossible to mould and cast it in metal. Yet nothing is more common, and the cherished pattern has frequently to be cast aside and replaced by one of totally different construction. A pattern maker, in addition to skill in the use of tools, must be able to make drawings and sketches as well as read them, as it frequently happens that the pattern must have a shape differing from that shown in the drawing. He must therefore be able to make the modified drawings necessary for his work, and so must thoroughly understand the methods of the foundry. With these thoughts in mind the present series of articles are written.

These articles, then, are to take up also the principles of moulding and casting, and the series will be long enough to give instruction to such an extent that the model maker will be able to embody his ideas for castings in patterns, to adapt means to ends, and to avoid making the final results subservient to means. I hope to be able to explain foundry practice in such a way as to prevent the reader from making any mistakes in his designing, which might lead to expensive castings because of their being impractically designed and thus costly to make through defective knowledge of moulding.

Having finished our introduction, let us first examine very briefly something of the history of pattern making. The art of moulding has come down to us from a very remote period we find evidences of its practice by the most ancient nations in articles found among the ruins of temples, palaces, fortresses and cities. Those learned men, who have read our old earth's unwritten history, tell us that in ages far remote, men made tools and contrivances of bronze, which being an alloy, necessitated the fusion and casting of the metal. This casting involves the use of patterns, and pattern making may therefore lay claim to the highest antiquity.

Lack of space forbids any lengthly review of the history of pattern making, and I will only say that, whatever the source of the technology of the art, we in our own day can show nothing superior, either in design or execution, over the work of men whose names and methods are lost. The more modern idea of the division of labor has made pattern making a distinct art. A generation ago a machinist was required to be able to work upon both wood and metal; he constructed his frames of wood and made the patterns for his cast metal work; he was today a woodworker, tomorrow a lathe hand and the following day a vise hand.

In this art, there are to be considered many details that are seldom or never shown in drawings, such for instance, as the amount necessary to allow on the pattern for finishing certain parts of a casting, and on what part such allowance is required, and the method which has been proved by experience to be the safest and most expeditious in moulding a certain kind of pattern. But above all these considerations lies the fact that drawings merely show the shape which the fin-

ished pattern is required to have, leaving it entirely to the judgment of the pattern maker to select in what way the various pieces of wood (of which the pattern is constructed) shall have the grain lie, and how they shall be fastened or held together. Experience is a great teacher, and the amateur should always keep a record of the work which falls under his observation, in which record the sizes and proportions of the work, the method of putting it together, the time taken in its production, and (if possible), whether the castings were satisfactory, noting the defects in the latter, if any, together with suggestions for the remedy for those defects. A pen and ink sketch of the patterns made in the margin of the record will add to its usefulness, besides accustoming the hand to make correct sketches and a clear explanation of the work done. The operative's intelligence will be much exercised in the shaping and building up of patterns, depending as this does on the strength of the material of which the casting is to be made, the strength of the pattern itself and the desirability of its moulding well.

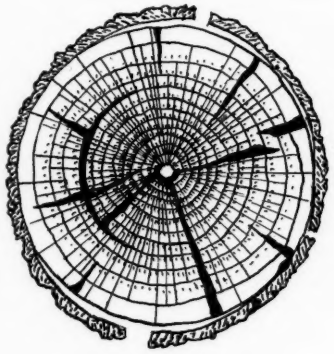


FIG. 1.

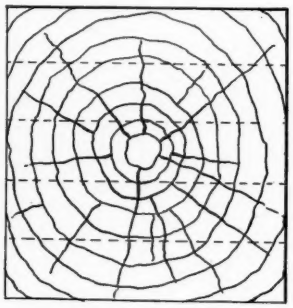


FIG. 2.

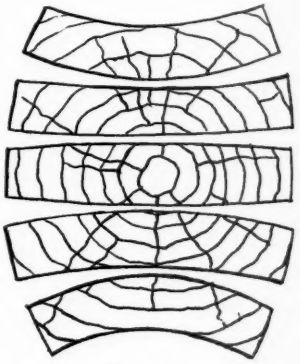


FIG. 3.

Before we commence the actual making of patterns it will be well to give some instructions as to wood and other materials to be used in this work and also to anticipate some of the difficulties that may be met in the use of tools, etc. In selecting stock for patterns the following must be considered: — First, its tendency to warp; second, its tendency to bend, and third, its tendency to shrink. Newly felled timber contains sometimes as much as 50 per cent of its weight of water. If it lies for some time in a dry and airy place it will lose nearly half its amount of water by evaporation. During the process of drying, timber decreases in volume or *shrinks*. If exposed again to moisture it increases in volume or *swells*.

Timber is often used under condition which do not permit it to shrink or swell freely in all directions; consequently it shrinks or swells more in one place than in another. When one part of a piece of timber shrinks more rapidly than an adjacent part, the wood *cracks*. If, on the other hand, one part swells more than another, or if the adjacent part meets with some obstacle to its expansion, the timber changes in shape, it becomes *warped*.

In many kinds of trees, when the trunk is sawn across, a considerable difference may be observed between the appearance of the inner and older and the outer and younger concentric annual layers. The inner layers making up the *heart* of the tree are generally firmer and closer in texture and darker in color than the outer or *sap* wood; these outer layers being less compact, lighter in color, and full of sap. The parts nearest the sap wood shrinks more rapidly than the heart wood and cracks or checks are the result.

Fig. 1 is a sectional view of a log showing very clearly the annular rings and the checks as just referred to. Fig. 2 is a sectional view of a log with the round edges removed, the dotted lines indicating the cuts taken in sawing the log into parallel longitudinal cuts. Fig. 3 shows how the planks will shrink as the moisture dies out. The broadest portion shown shrinks least in breadth,

most in thickness; least nearest the centre, most near the sides. The outside planks, however, shrink most in breadth, in the direction of the annual layers, and least in thickness. The planks lying between shrink differently on different sides, and become convex nearest the centre and concave toward the outside because of the corners being drawn up.

It will be seen then that planks containing the most heart wood warp the least, and so, in order to reduce the tendency to warp, the boards or planks are sometimes sawed at right angles to the annular rings, making four pieces. Each piece is then laid back down and sawed into boards. This method, called *quarter-sawing*, is wasteful in lumber but reduces warping to a minimum, and in certain kinds of wood, as oak and sycamore, produces very beautiful results on account of the manner in which it intersects the medullary rays.

For our work, pine will be the most servicable of the different kinds of woods used by the pattern maker. Good stock, straight grained and free from knots should be procured, as the difference in cost between good and inferior wood in the small pieces required for each pattern is as nothing in comparison to the value of the work put into it, and a pattern may easily become valueless through the wood being checked or not thoroughly seasoned.

Pine, if carefully selected, is easily worked and possesses, at the same time, strength enough for all but the most delicate kinds of patterns. The chief objection to pine for small patterns is that it is soft and soon gets dented from repeated moulding, but this objection we need not consider, as the reader is not likely to need more than three or four castings from the same pattern. Also, by carefully shellacing the pine patterns, we shall be able to make the surface very nearly as hard and glossy as hardwood ones, and so secure the same smooth castings.

When pine is straight grained, the marks left by the saw on a plank will show an even roughness throughout its length, the softer the plank the rougher the appearance of the edges. If the surfaces sawed seem to be smooth, the stock will generally be found to be hard and difficult to work. When the surfaces sawed are rough in spots and smooth in others, the grain is croodek and it will be found that in planing, the grain tears up and a smooth surface is impossible.

When a great many castings for fine work are required from a pattern, a pattern is made for an iron casting to be finished as a pattern. These iron patterns are very durable, leave the sand easily and will not warp. They are, however, expensive to make, and so mahogany is very extensively employed for fine or durable pattern work. Mahogany warps but little and does not decay, so it is really the most desirable of all woods used in pattern making, where the first cost need not be considered.

Bay wood, an inferior and much cheaper kind of mahogany is much used, especially in England. If you buy bay wood, choose it light colored and get it as straight grained as possible, and without any fancy markings. Avoid a board that is "fuzzy" or "wooly" on the surface as it does not work well, this being opposite to the grain of pine stock, which when rough from the saw is generally soft and easily worked.

Next to mahogany we may rank cherry. It is a very durable wood, but is much more liable to warp or twist than mahogany and is rather hard to work. Small patterns and core boxes are sometimes made from hard maple, while for very fragile patterns sycamore is sometimes used, as it is so white and close grained that you can draw neatly upon it, and see your lines distinctly when paring or carving, a most important point in accurate work. In buying small pieces of wood, I may say that most lumber dealers are willing to cut off a piece of board at a little extra cost per square foot. Do not buy, however, from a builder or cabinet maker if you can avoid it, as they will generally charge a much higher price.

It is reported that some students of Missouri University, at Columbia, Mo., have discovered that if an ordinary telephone transmitter be connected in a certain manner with an electric arc lamp, the latter will produce whatever sounds are made before the transmitter, and with greatly amplified volume. The arc lamp appears to act as a giant receiver, reproducing speech, shouts, laughter, etc., with immense volume.

BOOKS RECEIVED.

SILVERWORK AND JEWELRY. H. Wilson, D. Appleton & Co., New York, 7 ¾ x 5, 346 pp. 169 illustrations and 16 page plates. $1.40 net.

WOOD CARVING. George Jack, D. Appleton & Co., New York, 7 ¾ x 5, 310 pp. 77 illustrations and 16 page plates. $1.40 net.

These two books are the second and third to appear in the "Artistic Crafts Series of Technical Hand Books" which is destined, as the number and range increases, to become a valuable source of information and instruction. In the first book above mentioned, the author gives practical instruction in the use of the tools and the making of quite a range of metal work, including the hammered work now so popular in many manual training schools. The numerous examples illustrating the different kinds of work are all well selected and artistic.

The treatment of wood carving is essentially artistic, and because of this fact has decided value to a student of the subject who would avoid being misled in the early stages of his work, before his mind has been trained to clearly distinguish between good and poor design. The "technique" is described as clearly as the subject will permit, the tools and their appropriate uses, being shown by numerous illustrations. An excellent book.

MACHINE DESIGN, PART I. Charles L. Griffin, S. B. American School of Correspondence, Chicago, Ill. 9 ¾ x 7, 74 pp.

To those who are unable to attend a resident technical school, the correspondence system of instruction is of decided value. Thousands of men have utilized this method of increasing the knowledge with manifest advantage, both intellectural, and financially, to themselves and their associates. It is necessary, from the nature of the methods used, that instruction papers be plain and as complete as possible, to enable the student to make suitable progress without unnecessary loss of time. This paper on machine design certainly complies with these requirements, and contains much excellent instruction as to proper methods of working when original work is attempted.

"TECHNICS" is the name of a new magazine published by George Newnes, Ltd., London, for "technical students." If the high standard of the first number be maintained, it should certainly find many readers. Among the subjects there presented are:—Charlottenburg, the Berlin Technical High School; Radium, Mural Decoration, Modern Art of Dyeing, Textile Design, Elementary Technical Education, Continuous Current Dynamo, Rapid Cutting Steel, and others. The International News Co., New York, are American agents.

A new metal which is similar to aluminum, but still of lesser weight, has been discovered by the French engineer Albert Nodon, and called "nodium," after him. It is manufactured by an electric process. In color, luster, and structure it is almost exactly like steel. Its specific weight when molten is only 2.4. Its resistance against breaking is given as about 20 pounds per square of 0.04 inch. Its constancy in the air is higher than that of aluminum. Its ductility is between 6 to 8 inches; the malleability can be compared to that of bronze. It melts at about 600°. It is suitable for being cast into forms. The conductibility for the electric current is as high as that of copper of equal weight. If natural power especially water power, can be used for its manufacture, the cost in round figures is about 15 cents per pound. The inventor expects numerous uses of nodium in the near future, especially for electric wires and cables, for light but strong parts of motor cars, torpedo boats, men-of-war, street cars, military outfits, air ships, etc., and for castings in place of bronze, German Silver, and similar metals. Nothing definite has yet been communicated as to the chemical composition of nodium nor as to the mode of its manufacture.

One of the points of interest in the motor-car or automobile development is the fact that the facilities offered by up-to-date automobiles for traveling long distances quickly and easily, and without regarding to fixed time tables, increases the radius of the residential section of a city, thus combining the advantages of country life, with a command of city conveniences.

AMATEUR WORK

77 KILBY ST., BOSTON

DRAPER PUBLISHING CO., PUBLISHERS.

A Monthly Magazine of the Useful Arts and Sciences. Published on the first of each month for the benefit and instruction of the amateur worker.

Subscription Rates for the United States, Canada and Mexico $1.00 per year. Single copies of any number in current volume, 10 cents.

TO ADVERTISERS.

New advertisements, or changes, intended for a particular issue, should reach the office on or before the 15th of the previous month.

Entered at the Post-office, Boston, as second-class mail matter Jan. 14, 1902.

MARCH, 1904.

The article on the "Hot Air Engine" in this issue is to be followed by one on a "Dynamo" and one on a "Storage Battery;" all of about the same capacity, making together a nicely designed combination which should be of much interest to our readers.

Our premium offer of turning lathes is meeting with the success which we felt certain it would when making the same. Two letters received from fortunate winners, and given in this issue, are the best testimony we can offer as to the value of these premiums. As a lathe is such a necessary tool to the amateur, and as our offer places a good lathe within the reach of nearly every reader of the magazine, we feel confident that many others will be equally successful in securing lathes at an early date. As we have a large stock on hand, and in process of manufacture, premiums will be sent promptly on receipt of the necessary subscriptions. We also announce that the following accessories are being designed and made, which will add materially to the usefulness of the lathe; — Saw table for circular saw, 3 inch for metal and 5 inch for wood; saw arbor for same and for 5 inch emery wheel; drill chuck for holding drills, and fret saw attachment. We shall probably be able to announce terms for securing these attachments in the next issue.

The financial demands of model making and experimental work are frequently greater than some of our younger readers find it convenient to meet with their ordinary income. If they could carry on a little business, which would be dignified and agreeable, and yet not interfere with school or home duties, their income could be considerably increased. To assist such of our readers as will be interested in a business of this kind we make the following offers; — The premiums given for three subscribers will be given;

1. For the best article telling how boys can make money, without capital, in a place over 10,000 inhabitants.
2. For the same, without capital, in place under 10,000 inhabitants.
3. For the same with a capital not exceeding $5.00 in a place over 10,000 inhabitants.
4. For the same in a place under 10,000 inhabitants.

All articles must be received not later than April, 10, 1904. Articles not awarded a prize, but which are of sufficient interest to publish will be awarded a premium given for one subscriber. Articles should contain not over 300 words, be written on one side of the paper with one inch margins on all sides.

WEST LYNN, March, 3, 1904.

DRAPER PUB. Co.,
BOSTON, MASS,
Gentlemen:—

The lathe was received in O. K. condition, and I want to state that it is a little beauty; more so than I expected. I set it up the same afternoon received, and had it running. It is a very smooth running machine, and will make a very handy tool. I would like to recommend it for both amateurs and professionals; especially the easy way of getting it. I shall be pleased to show it to anyone interested, living in my locality. It is worth trying for twice over.

C. A Carlsson.

ALLSTON, Mass, March, 2, '04.

DRAPER PUB. CO.,
BOSTON, MASS,
Gentlemen:—

The lathe received and in first class condition. The scraped bed was an additional surprise to me. The alignment was correct and the bearings stood four hours continuous running without heating. I am much pleased with the lathe, and earnestly recommend it to all readers of AMATEUR WORK.

A. Gordon Hentz.

HOW TO MAKE A SET OF WEIGHTS.

Robert Gibson Griswold.

The following described set of weights is intended to go with, or be used with, the balance described in the last issue of Amateur Work. The balance cannot be of much use without a set of good, accurate weights, and while the set if purchased from the maker's would be very accurate, they would cost about $10. Since every weight must be made by hand, however expensive it may be, the amateur can make them as well as the manufacturer.

In the first place, a set of weights need not be exactly a counterpart of the international standard, which the manufacturers always make them. The value of any set of weights lie in their being exact multiples or sub-multiples of each other, as every weight is simply relative and nothing absolute can be made. The system of weights generally used in all technical work, especially chemistry, physics and photography, is the international gram, the equivalent of which is a cubic centimeter of distilled water at its maximum density.

Now when a formula requires that the weight of a certain substance shall be say 9.647 grams, and that another ingredient shall weigh 7.523 grams, it makes no difference whether the weights with which the above ingredients are weighed out are exactly duplicates of the international standard or not, so long as the system to which the respective weights belong exactly agrees with its several units. To make this still plainer, the weights merely express the number of parts to be taken, so that if the unit to which the part is referred is the same in each case, the ratio between the ingredients will be correct.

Now in order that a starting place may be had from which to work, it will be necessary to borrow from some druggist or chemist a few weights for comparison. We will consider the making of the set of metric weights specified in the accompanying table denominations.

The above set will permit accurate weighings to be made from 200 grams down to 1 milligram, a range that is generally sufficient for all purposes. The combination given will permit any weight being readily ascertained with the greatest ease, giving the least number of trials. The writer prefers, in the case of the small weights, to make them of aluminum wire, as the pieces are larger and more readily handled than those made of foil. For the milligram weights use No. 34 B. & S. guage; for the tens of milligrams, use No. 28 or 30, and for the hundreds use No. 20 or 22. The larger weights are turned out of brass rods to the dimensions given below.

100 grams.	.5 grams =	500 milligrams.	
50 "	.2 "	200 "	(2)
20 "	.1 "	100 "	
10 " (2)	.05 "	50 "	
5 "	.02 "	20 "	
2 " (2)	.01 "	10 "	(2)
1 "	.005 "	5 "	
	.002 "	2 "	(2)
	.001 "	1 "	

We will start with the milligram weight first. Adjust the balance accurately so that the needle swings to zero and stops there. Now place one of the borrowed milligram weights thereon and place on the other pan a short piece of the No. 34 wire and keep repeatedly trimming off the end with a sharp pair of scissors, or better yet, a sharp penknife, cutting down on to a piece of sheet zinc until it almost balances. Now remove the milligram weight and place on the pan holding the wire, which has been removed. and exactly balance it with small grains of sand. This balance must be absolutely exact or else the following process will be of little value.

When a balance has been affected, remove the milligram weight and replace it by the piece of wire just cut. Now with a very smooth cut file, that has been boiled in soda to remove the film of grease always present on new files, and thoroughly dried, carefully file off the end of the wire and try its weight until it exactly balances the sand on the opposite pan and the needle stops at zero when through swinging. This is known as the method of substitution, and is the most accurate method of weighing in the ordinary balance that is yet known. It insures that the com-

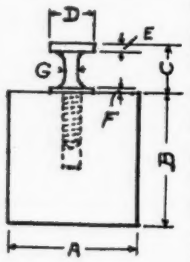
pared pieces shall be of exactly the same weight, regardless of the difference in the length of the two beam arms, however small this difference may be. This finishes the milligram weight. It should be particularly impressed that no weight should ever be touched by the fingers; always pick them up with a small pair of tweezers and if it is necessary to hold them in the fingers, do so with a piece of linen or silk between them and the skin. The skin is continually exuding moisture which will tarnish them.

Now place the two milligram weights on the pan together, and add more sand to the opposite pan until a balance is again secured. Cut off a piece of the wire slightly more than twice the length of the first piece and carefully adjust this by the method just given until it weighs exactly two milligrams. Then make another exactly like it. In the table given above those weights followed by the figure (2) are to be made in duplicate. We now have two two-milligram weights and a one milligram weight, the sum of which is five. Place the three on the pan together and balance with sand as before. Then cut another piece of wire as long as the three and adjust in a similar manner. If the work has been carefully performed the weights will be exact multiples of the milligram weight and the sum will be ten milligrams.

Now balance the ten milligrams against the ten milligram weight of the borrowed set and see that they balance perfectly. If they do not, go over the work carefully and see where the error lies. The ten milligram weight must balance these four weights just made, and the two 20's and 50 are made in exactly the same manner. All these wires should be bent into distinct shapes, the two's and 20 being bent into a V shape, the two arms indicating the denomination, and the five and 50 being bent into a pentagon or five sided figure.

The hundred milligram weights are made in a like manner, great care being taken to see that a strict multiple ratio is obtained in each. These fractional weights are the hardest to make and require considerable patience, but if well made are more than worth the time and trouble; and, furthermore, one has the knowledge that they are strictly accurate with each other, which is far more important than the material of which they are made or their respective shapes.

The larger weights are all made of brass and lacquered, the lacquer being put on and baked before they are adjusted. It is common to make the little handles loose and screw them into the weights, which permits of the adjustment being made on them by filing and then, when they are screwed into place, no bare metal is exposed to the action of dampness or fumes. Below is given a table of sizes to which a set may be turned up and afterwards adjusted. Of course it will be impossible to give a size that will be exact in every case, since the density of the metal will vary greatly in different compositions. But the figures will be a guide, and if the knobs are made loose and screwed into the weight, very little adjusting will be necessary and that only on the in side. If the weights are light, small pieces of tin-foil can be put in the hole before the knob is screwed in. This loose knob is provided merely to allow the entire outer surface to be lacquered, which it could not be if the adjustment had to be made by filing metal from the outside.



If the above set is carefully and properly made it will be well worth the time and trouble and with care in handling will last a lifetime. Weights should never be handled with anything but a pair of tweezers and they had best be ivory tipped. Make a neat wooden block and drill holes in it that will just fit the weights and always keep them in their respective places. The value of the weight may be stamped on its knob and also beside the respective holes in the block. Only slight depressions need be made for the fractional weights and they should be kept covered with a strip of glass. A cover should be provided for the block to exclude dust.

Value	A	B	C	D	E	F	G
1	13-64	9-64	17-64	5-32	3-64	1-64	3-64
2	15-64	5-16	15-64	11-64	3-64	1-64	3-64
5	33-64	3-8	1-4	3-16	3-64	1-64	1-16
10	7-16	33-64	17-64	7-32	1-16	1-32	1-16
20	9-16	19-32	1-4	1-4	1-16	1-32	1-16
50	25-32	25-32	1-4	1-4	1-16	1-32	1-16
100	1 1-16	55-64	1-4	5-16	1-16	1-32	1.16

HOW TO BUILD A SAILBOAT.

CARL H. CLARK.

III. Making the Frame.

The next things to be gotten out are the moulds, or temporary forms, upon which the boat is shaped. There is one of these for every cross section laid out on the floor. They are made to the inside line of the cross section, as already mentioned, since they fit inside of the plank. Numbers 2, 3, 4, 5 are made as shown in Fig. 7, being cut out to fit over the centreboard logs, while the others are made as in Fig. 8. For this purpose any kind of cheap stock may be used, but they must be well braced and strong, as they must

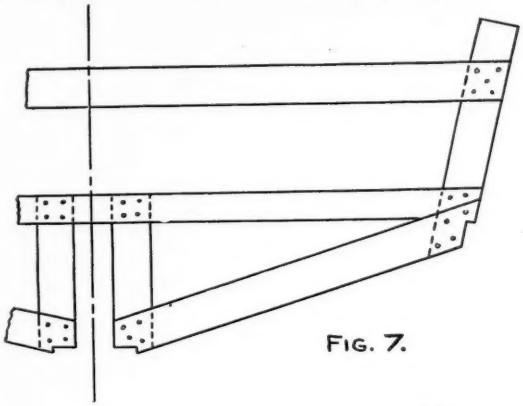


FIG. 7.

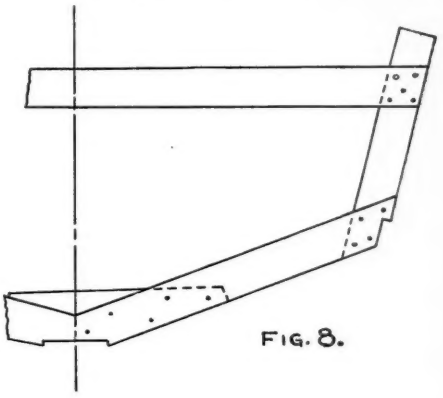


FIG. 8.

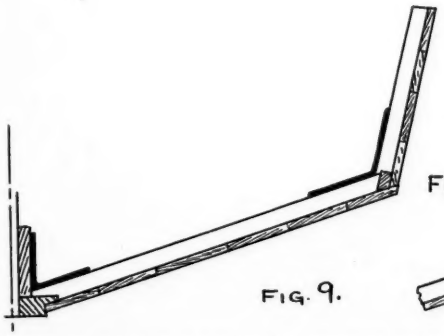


FIG. 9.

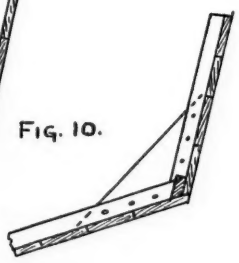


FIG. 10.

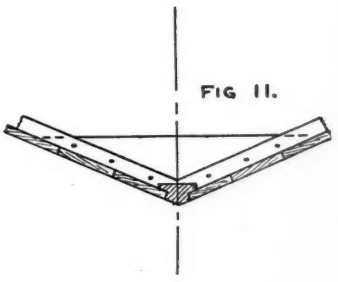


FIG 11.

be able to stand a considerable amount of strain. They must also be an accurate reproduction of the lines on the floor, and be alike on both sides. The projecting side pieces are left to fasten braces to. The centre lines should be marked across the lower part and also across the top brace, for use in setting up. The notch in the corner is made to fit a $2\frac{1}{2}'' \times 1\frac{1}{2}''$ piece, which is to be later fitted into place and beveled off to make a smooth surface. The top cross brace may be well fastened at the correct sheer height to make it easier to bend on the top strake of plank.

The moulds are set up in place on the keel at the proper points. It will be noticed that in the plan, the forward moulds are placed with their after faces on the mould line, and the after ones with their forward faces on the mould line. The reason for this is that the shape is desired at the mould point, and on account of the bevel, this would not be obtained otherwise. It will be necessary to bevel off the bottoms of the moulds somewhat to make them conform to the slant of the keel. They must be set up perfectly plumb or square with the W. L. and also square with the centre line fore and aft. The line already stretched from the middle of the stem to the middle of the sternboard, will help in setting them upright. A ribband 3″ or 4″ wide should be bent around near the tops and screwed to them and the stem and sternboard with screws to hold them in place. They may be test-

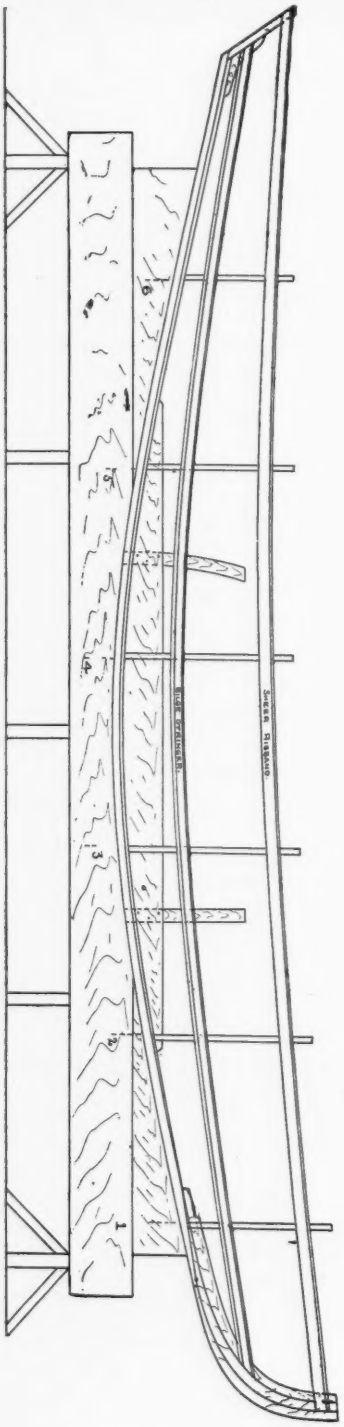


FIG. 12.

ed for squareness with the keel by measuring from the stem around this ribband to the mould, which should give equal lengths on both sides if the mould is square.

The center line marked on each cross piece will, when correctly set up, be directly under the line fore and aft. After the moulds are all adjusted, their fairness should be tested by bending a batten or thin board around them. If the board does not lie flat and even upon them the discrepancy should be noted and its cause looked up. It is always possible that small inaccuracies may occur during the process of transferring the shapes from the designer's drawing to the finished mould. Any small discrepancies may be left for correction until the moulds are ready to bevel.

The moulds are fastened temporarily to the keel by blocks of wood or small iron angle braces; the latter is best as fastening must be firm. When the moulds are all fairly in place they are braced diagonally from the braces overhead and also across the tops to each other and to the stern. In fitting the plank there is considerable strain brought upon the moulds and the bracing must be strong enough to stand it.

It has been noted that when the batten was laid on the moulds, it bore only on the corners. These corners must now be beveled off until it lies evenly on the surface, the whole thickness of the mould. The reason for placing the moulds as was done will now be seen, as the shape is only maintained at the edge nearer the middle of the boat; this edge being on the mould point. The corner piece $2\frac{1}{2}'' \times 1\frac{1}{4}''$ is bent around into the notches in each corner of the moulds. It must extend from the inside of the stem to the inside of the sternboard. At the stem it is let in a slight amount to give fastenings and on the sternboard it is fastened temporarily with amall angle braces which are later to be replaced with knees. This piece is designed to afford fastening for the joint between the side and bottom boards. One face of it is now flush with the top side of the mould as shown in Fig. 9, and the lower edge must be beveled off to the line of the bottom face as shown by the dotted line. This angle changes all fore and aft and can only be gotten exactly at each mould, and between the moulds it must be cut by the eye. This allows the bottom plank to lie smoothly and be fastened to the bilge stringer.

The stringer is fastened temporarily to the moulds to hold it in place and keep it from springing out of the notches. The rabbet in the keel must now be cut out evenly all along to conform to the varying angle of the bottom. It must be so cut that when a piece of board is laid on the mould, it will fit squarely into the rabbet and make a neat joint. The angle changes at all points and between the moulds it must be trimmed until a piece of board laid on the bilge stringer will fit squarely into it. At the stem the rabbet can be fitted by bending a narrow piece of board around the moulds and cutting to the proper angle. This rabbet is to be carefully cut and fitted, as the

tightness of the garboard seam depends upon it. Before exerting any pressure upon the stem it should be braced sideways and have a brace under it extending to the floor to make sure that it is not forced out of line.

The planking should be either of pine, cedar, or cypress as is most convenient. It must be well seasoned and dry, in order not to check and shrink after being fastened into place. If possible, it should be in lengths long enough to extend the entire length of the boat without joints or butts, as this makes a smoother piece of work, besides being much easier. It should be noted that on account of the curvature of the side of the boat, the planks have a curve, or spiling as it is termed, which necessitates the board being considerably wider than the plank which is gotten out of it. The boards then, should be gotten as wide as is convenient, and planks worked out of them as wide as possible, up to about 6″ wide. Too wide planks are not desirable, although they make fewer seams; the wide planks, however, are likely to check and split. It is not necessary that the plank should be entirely free from all knots, as small, tight knots are not at all a detriment, but rather add to the strength of the plank, and tend to prevent it from checking. Large, loose knots and weather checks, must however, be avoided. The plank should be ¾″ in thickness.

The planking may now be started. It is to be fitted on the topsides first, about four stakes being probably required. The top strake would best be fitted first, as it defines the sheer outline. The marks of the sheer are already on each mould and the stem, and it is only necessary to lay the plank on in place and mark it according to the marks on the moulds. With the batten, a fair line is drawn through these points. The width to be covered on each mould should be divided equally according to the number of plank it is intended to put on. The width of the top strake is then transferred from the moulds to the board, and a fair line struck through these points, thus outlining the lower edge of the plank.

The edges of the plank should be smooth and square. Where the plank joins the stem the curve can be obtained by clamping the plank on in place and marking across it to fit the rabbet. The end may then be allowed to spring out and be trimmed off to fit, the plank remaining in place. It may be sprung back and any further trimming noticed. It should be a neat fit for the rabbet and at the stern should project beyond. The plank for one side may be used as a pattern for the corresponding plank on the other side, thus saving all but the final trimming. The lower edge of one plank may also be used as a pattern for the top edge of the next plank below, and should be transferred to it before fastening in place. The top strake may now be fastened in place permanently. It should be clamped in place on the moulds and forced tightly into its place in the rabbet of the stem, where it is secured with brass screws or galvanized boat nails. These fastenings should be countersunk by boring in about ¼″ deep with a bit large enough to take the bead. The plank should also be fastened temporarily to each mould with long slender screws, working from the bow towards the stern. At the stern it should be fastened with brass screws, the same as at the stem. After fastening at the stern the plank should be cut off about 1″ beyond and left rough. The second plank should be fitted in the same manner. The seam between planks should be close on the inside and just slightly open on the outside to allow the insertion of a thread of calking. These directions also apply to the succeeding strakes below.

The lowest strake of side planking should be fitted last. This strake extends to the lower edge of the bilge stringer and is beveled off to the same angle to take the bottom planking, This lowest strake, besides being fastened the same as the others is also fastened permanently to the bilge stringer throughout its whole length, either with brass screws, or galvanized boat nails driven through and clinched on the inside of the bilge stringer. If nails are used they should be clinched across the grain, and care taken not to split the bilge stringer in clinching. If it should be necessary to make a butt joint in any plank the ends should be brought together to a good fit and a block abont 8″ long fitted on the inside over the joint aud the ends fastened to it with boat nails, clinched over. These joints must be so placed that the blocks will come between frames. There are three of the latter between each two moulds, 9″ apart on centres. The proper position for the joint can thus be easily found.

The lower edge of the lower topside plank is to be beveled off to the same angle as the bilge stringer, so that the bottom plank will lie smoothly across both. This angle can be verified by bending a thin board over the moulds and trimming off to fit. The bottom plank is next in order. This plank is put on starting next to the keel and working outwards. The garboard strake or plank next to the keel is the first to be fitted. On account of the slope of the bottom, this plank will have a considerable amount of curvature and the "spiling" will require to be taken.

To obtain the spiling of the plank, a thin board with one straight edge is used. This board is laid on the moulds near the keel and clamped in place. The crossing of each mould is marked on the board and the distance measured from the edge of the board to the inside of the rabbet at each mould. The board is then transferred to the stock from which the plank is to be gotten out, and the same distances already measured, are laid off from the edge of the board. Through the points thus laid off a fair line is struck with the batten. The edge is trimmed to this line and is finally fitted by bending into place alongside the keel. These garboards must be very carefully fitted and lie fairly in the rabbet all fore and aft.

It is especially desirable that the garboad seam should be tight, as otherwise it is a source of much trouble and annoyance.

The upper edge of the garboard strake is left straight and at the bow is carried to meet the curve of the lower edge. This plank is fastened permanently to the back rabbet on the keel and stem and also to the sternboard if it extends so far. Owing to the width of the plank and its curvature it may taper out before reaching the sternboard, but it can be fastened securely to the keel. It is secured to the moulds with slender screws. The next, and the following planks, are cut in the same manner and fastened temporarily to the moulds with screws. The outer planks of the bottom will land across the bilge line, and are to be nailed to the bilge stringer and to the lower plank of the side. The bottom planking, where it extends beyond the bilge line, is now to be trimmed off even with the side planking and smoothed down. The bilge stringer, together with the side plank, give a double row of fastening and make a good tight joint. All the joints in the bottom should be close inside and slightly open on the outside. As fast as a plank is fitted on one side the corresponding plank on the other should be fitted, using the first as a pattern.

The frames are next to be put into place. They are of oak, or other hard wood, and are 1 ½″ x 1 ½″, and are put into the boat with the 1 ½″ dimension vertical. As before stated, they are spaced 9″ on centres, or three between each two moulds. The frames are in two parts, one extending from the keel to the bilge stringer, and the other from the bilge stringer to the deck. The bottom frames are fitted between the keel and the bilge stringer, being notched out to fit the keel, and extending on to it as far as possible, to give a good fastening to it. A nail or two should be driven through the end of the frame into the keel, taking care not to split either the end of the frame or the back rabbet of the keel. The plank should be fastened to the frames with copper or galvanized boat nails. If the latter are used they should be bored for and clinched over across the grain of the frame, and carefully, to not split it. If copper nails are used they are cut off about ½″ above the surface, a burr, or washer is slipped on and the nail is headed over, a heavy hammer or other weight being held against the head.

The copper nails are much to be preferred, as they draw the plank up very tight. Brass screws can be used for fastening the plank in place; in many instances they have given good satisfaction, but the writer does not recommend them for this purpose. The side frames extend from the upper edge of the bilge stringer to the top of the sheer strake already in place. This frame, being 1 ½″ deep can be cut out to fit over the bilge stringer and make a clean corner with the bottom frame.

As the boat now stands she would be weak at the bilge and to remedy this, some sort of brace must be fitted. A corner angle of galvanized iron 1 ½″ x 3-16″ is recommended as being very strong and taking up no room. It is fastened with rivets extending out through the plank. Fig. 9 shows the general idea of the frames and corner braces. If it is not desired to go to the expense of the corner braces, a corner piece of wood may be fitted as in Fig. 10, with the grain running as shown; a curved knee would, however, be better and would take up less space inside the boat. The tops of the side frames can be cut off even with the top of the upper strake of side planking. Towards the bow the bottom frames will require some fitting to make them conform to the twist in the surface. In fact, it will facilitate the fitting of knees and floors if all the frames are beveled so that they stand both plumb, and square with the centerline of the boat, and not square with the outline of the side.

Forward and aft of the centerboard box the frames, where they cross the keel are to have a floor, or cross piece fitted, to connect the two sides of the frame across the keel. These floors may be either of galvanized iron 1 ½″ x 3-16″ or natural crook knees set on the top of the floors, or a piece of oak about 1 ½″ x 1 ½″ may be steamed and bent into place across the keel and fastened through planking. A still simple way is to use a piece of board about ½″ thick with the grain, as shown in Fig. 11, fitted at one side of the frame. It is notched down over the keel, and fastened to the frame and also to the plank independently of the frame. This method, although quite general, is not as good as others. The frames in the way of the ce n treboard box should have angle braces fitted into the corner and screwed to the centreboard logs.

As has been before noted, there are three frames between each two moulds. Those between the moulds should be fitted completely and all the fastenings driven and knees put into place. The moulds may now be removed and a frame put into the place of each, using the holes made for the screws, to take rivets, thus leaving fewer holes to be filled with putty. The ends of the planks, where they project beyond the sternboard, must be planed off smooth with its surface. The plank should not be planed on the outside until later. It will, however, be wise to give the planking a heavy coat of oil and then paint the inside with one coat. This will prevent its checking and shrinking during the remainder of the work. Fig. 12 shows the keel with the moulds set up in place, and the bilge stringer fitted ready for planking.

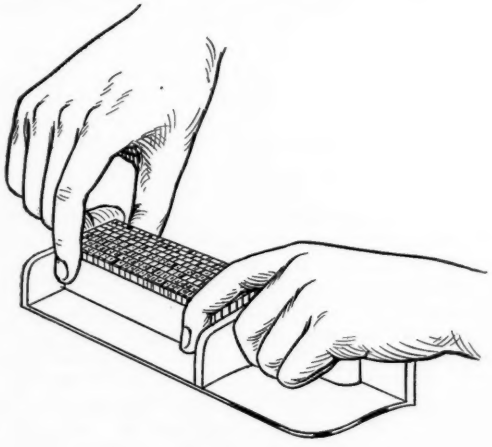
It is stated that during the recent conflagration at Baltimore, a watchman remained locked in a bank vault located in a building which was burned to the ground. It was the custom to lock the watchman in the vault Saturday night, with food sufficient to last till Monday. The fire prevented his release; when the debris was cool enough to admit of opening the vault on Tuesday, the watchman came out smiling.

PRINTING FOR BEGINNERS.

FREDERICK A. DRAPER.

V. Emptying the Composition Stick and Distribution.

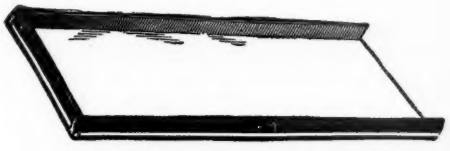
When the composing stick has been filled it has to be emptied on to a galley. The illustration shows the position of the hands when doing this. The first efforts of the beginner should be made with the stick only partly filled, the full stick being attempted when experience has been gained. Also, in making the first trials, it is advisable to rest the stick upon a galley, as, in case of failure, the type will then be more easily held in place. In removing the type from the stick, the forefingers of each hand press firmly against a lead placed against the outside of the last line of type; the thumbs press against a lead or composing rule outside the first line of type; the two outer joints of the second fingers press against the ends of the lines, thus holding the type on all sides. The other fingers of each hand press against the stick to hold it while the type is removed through the open side of the stick and placed upon a galley.



EMPTYING THE COMPOSING STICK.

As soon as the type is free of the stick, bend the wrists to bring the type matter to a vertical position, in which position it is carried to the galley. Care should be taken not to relax the pressure of the fingers at any time while the type is being removed or carried about. With very wide measure, the fore-fingers are applied to the type matter at such a distance from the ends of the line, as will give an even pressure to the whole length of lines, and it is frequently necessary to slide the type out of the stick on to a galley, so that, in bringing it to a vertical position for carrying, this may be done with a quick movement, thus preventing the centre of any line from falling out.

When all the type matter is composed and assembled upon the galley, it is tied firmly with strong cotton twine as follows; Beginning at the free corner, wind the twine 10 or 12 times tightly around the type, having the turns overlap each other. A bodkin or the end of the composing rule is put down between the type and the several turns of twine, with the last turn on the inside; the end is then brought back on the outside of the bodkin or rule forming a loop. The bodkin or rule is held at an angle towards the right, and by pulling on the end of the twine the loop will work down the bodkin until it projects on the under side of the turns of twine.



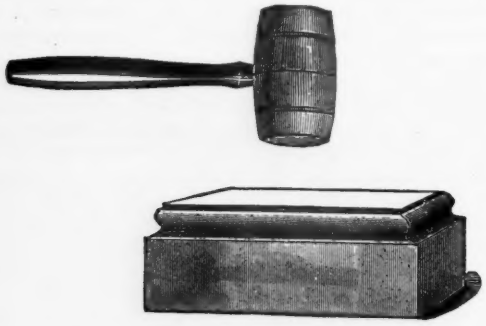
CALLEY.

Pulling the end of the loop will carry it back against the corner of the type where it will bind. This method of tying is secure, yet allows a quick removal of the twine by simply pulling on the free end. After fastening with the loop as above directed, press the twine down at the corners until about half way between the top and bottom, for, unless this be done, the tension of the twine is sufficient to cause it to slip upwards when moving the type from the galley, and perhaps cause several lines at each end to "pi."

HAND ROLLER.

It is customary, after tying up the type, to take one or more proofs. If a proof press is available, the type is placed thereon; inked with a hand roller, a piece of paper of suitable size to give ample margins for corrections, is laid upon the type and an impression taken. As many amateurs are not provided with a proof press, the following method will enable good proofs to be

secured, if care is used in taking them. Ink is placed upon a slab of marble (tiles about one foot square answer admirable for a small shop), a hand roller is run over it several times to distribute the ink evenly; the type is then inked with a light and even pressure of the roller; the paper is moistened on one side with a fairly moist sponge, the dry side placed upon the type, and firmly and evenly impresed upon the type with a proof-planer, upon the top of which firm, but

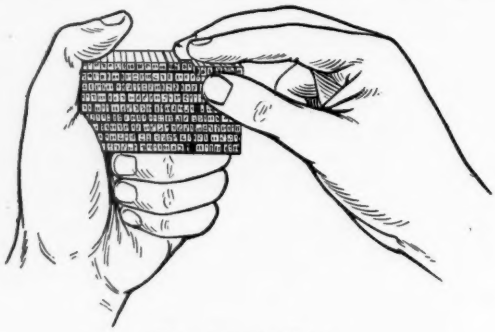


Mallet and Planer.

not very heavy blows are given with a mallet. The paper is then removed by taking hold of one edge or end and pulling in the direction of the opposite edge or end. A little practice will be necessary before this can be well done, the necessary requirements being; a hand roller in good condition, the right amount of ink evenly distributed on the stone and type, paper of good surface and strength and properly moistened.

After taking a proof, the ink remaining upon the type is washed off with benzine applied with a long handled bristle brush. The brush is saturated with the benzine and the type scrubbed until the ink is thoroughly removed. Electrotypes and process cuts are more easily cleaned by using cotton waste, wet with the benzine. It is quite essential to thoroughly clean the type, as if this is not done, the ink will settle around the joints and there harden, giving an uneven surface to the sides of the type, and causing them to stand unevenly. Justifying the lines and good press-work will thus be made a difficult matter to obtain. After printing large editions, and following continued use of type, it is also customary to wash with a solution of lye, this being more efficient in removing ink than is benzine. It should be a rule rigidly observed that the type be kept as clean as possible. The benzine must be stored in "Safety" cans, this being a regulation of insurance companies, and only a small quantity can be kept on hand. A one quart can is a good size, this quantity costing about ten cents, and lasting for some time in a small shop.

Omitting for the present the locking up the type in the chase and the press-work, and assuming that these have been completed and the type again in the galley, the next operation is that of distributing it into the case. The type is first wet down with water applied with a sponge. This has the effect of holding the type together, and yet allows of easy separation when throwing in. A quantity of type matter equal to about a stickful is taken up, as previously explained for emptying the stick, and supported in the left hand as shown in the illustration. The second, third and little fingers are turned inward forming a support for the type, which is steadied at the back by the fore-finger and on the end by the thumb. As with composition, the nicks are uppermost, the letters being read upside down, and the end of the line to the right.



Distribution Type.

With the end of the second finger of the right hand, push the end word a little to the front, grasp it between the fore-finger and the thumb, having by this time read it, and drop each letter in the proper box. This release of each letter is affected by pressure of the finger and thumb, assisted a little by the second finger. The thin letters will cause most trouble at first, care being necessary to hold a thin one after dropping a thick one, but the ability to do this will be readily acquired with practice. Care must also be used with the spaces, the different sizes being kept separate. It is an easy matter to drop them all into the box at the lower edge of the case, but this only means trouble, and loss of time when composition is again done from that case, and nothing is gained by lack of care in this matter. Extra characters should also be carefully laid in an extra stick or other receptacle, and thence in the proper case, to avoid possible loss or mislaying them where they cannot readily be found when wanted.

It will be noted, from what has here been said that an orderly method of work and arrangement of materials is absolutely necessary to proper and economical work in a printing office, and the more this idea is followed the better will be the results and greater the profits.

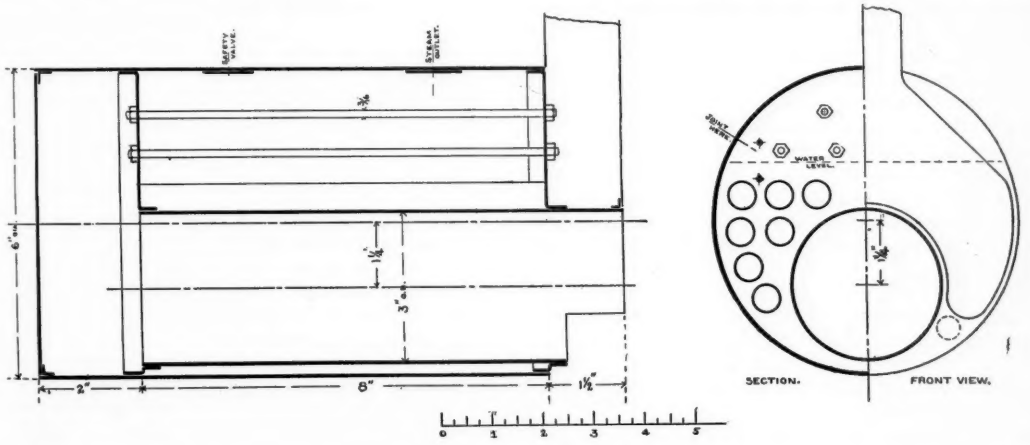
Those who have already secured Amateur Lathes, state they are more than pleased with them.

A MODEL STEAMBOAT.

CARL H. CLARK.

III. The Boiler.

The boiler here described is of the type known as the Scotch cylinder. The shell is 6″ diameter and 8″ long. It is rolled up from a sheet of copper 8″ wide, 19 ¼″ long and 3-32″ thick. It is to be rolled up exactly circular and riveted together with a lap of ⅜″. The rivets should be in a double row and zig-zag spaced. They should be of copper 5-32″ diameter, with round heads and should be spaced quite closely together. The riveting must be carefully done, and then riveted and worked up into as much of a head as possible, to draw the ends of the sheet tightly together. As this riveting is a matter requiring some skill it will be well for the amateur to sweat a layer of solder along edge of the joint both inside and outside after riveting to insure thickness.



It may be possible to procure a piece of seamless drawn copper or brass pipe of the required diameter and about 5-64″ thick. Brazed pipe must not be used as it is not strong enough. The openings in the shell are, one for the safety valve and one for the steam outlet. A reinforcing piece 1-16″ thick should be riveted on the shell under each. The holes are to be drilled later. The furnace is a tube 3″ diameter, 1-16″ thick and 9 ¼″ long, with its outer end cut away as shown. Seamless drawn tube must be used for this also.

The heads are 7-64″ thick, with the outer edge flanged to fit inside the shell and a flanged hole to fit over the furnace. About ¼″ should be allowed for flanging and it is accomplished by cutting out a circle of hard wood of the size of the inside of the flange, laying the blank upon it and hammering the edge lightly all around. The effect of this hammering will finally be to shrink the metal and form the flange. The flanged hole is formed in the same manner by hammering the edge over into a smooth round hole. The edges of the flange are then trimmed off to ½″ wide. This flanging is a nice piece of work and requires much care and patience. The flanges must be round and at right angles to the surface of the plate in order not to warp the shell when riveted together.

The front head should have reinforcing plates at the points shown, for the gauge glass, and below the furnace as shown by the dotted circle about ¾″ diameter. There are 7 tubes on each side, 9-16″ outside diameter, for which the holes should be now drilled; they should be spaced alike on each head. The holes in the back head should be a trifle smaller than the tube and those in the front head a trifle larger than it; 3-16″ holes for the stays are also to be drilled as shown. They should divide up the space between the tubes and shell so that each will bear as near as possible its share of the load produced by the steam pressure on the front head.

In setting up the boiler, the front head is first inserted and riveted in place. The position of the joint in the shell in regard to the furnace should be noted; and the head placed accordingly. The furnace is next adjusted to the opening in the back head and riveted up. The back head and furnace are then inserted from the back, the furnace projecting through

the front head the proper amount. The furnace mouth is next riveted and lastly the back head. The rivets for this purpose are about 5-32″ diameter, and are spaced about 5-8″ on centres in a single row. The holes should be drilled through both pieces at the same time to be sure of a good bearing, and care must be taken that no chips or filing are between the bearing surfaces to prevent a good bearing.

As the foundation of these joints, to be perfectly steam tight, is a very nice piece of work, it may be well for the amateur to solder all the joints to insure that they shall be tight. It must be borne in mind that no dependence is to be placed upon the solder for strength as this must be supplied by the rivets. The tubes are 9-16″ outside diameter, about 1-32″ thick, and long enough to extend from outside to outside of heads, and leave about ⅛″ on each end for heading over. The back end of the tube is to be filed slightly until it just enters the hole in the back head, and the front end of the tube is to be expanded somewhat by driving in a taper plug until it is a close fit for the hole in the front head. The tubes will pass easily through the hole in the front head, and are driven up to a good bearing making a tight joint with both heads. With a ball pine hammer the projecting end of the tube is now headed over. The ends of the tubes are cleaned and a ring of solder sweated into the corner around the ends of each tube to insure tightness.

The stays are 3-16″ diameter, spaced as shown. If possible the ends of the stay, which are threaded, should be upset so as to make the diameter at the bottom of the thread 3-16″ and thus preserve the full strength of the rod. The nuts are screwed on to give a slight pressure without distorting the sheets. Under each nut a round washer ½″ diameter and 1-16″ thick is to be placed to further support the sheet. All the stays should have as near as possible the same tension. After they are adjusted the end of the thread projecting through the nut is riveted over and solder sweated around the nut and washer to make it tight. The back sheet is of brass 1-16″ thick and a loose fit for the back of the shell. It is not necessary that this should make a tight joint, as it merely guides the flame around through the tubes and forms a combustion chamber. It is held in place by eight angle lugs screwed to it and riveted to the shell. The inside surface of the back sheet is to be covered with asbestos, as any heat passing through this sheet is a loss. This sheet should be so fastened in place as to be removablewh, en desired, to repair leaks or for other purposes.

The up take, or smoke box leading to the funnel is formed of thin iron or brass sheets of the shape shown to fit over the ends of the tubes, and rest on the projecting end of the furnace tube. The upper end must be worked into the round of the funnel which is about 1 ½″ in diameter. The front is held by a small angle fastened to the top of the furnace. It should be removable to get at the tube ends. When the boiler is complete it should be tested. A hole should be drilled in position for the steam outlet and connection made to a small force pump. The boiler is filled with water, and pressure is put upon it with the pump. Any leak will be seen by the water coming out. In place of a force pump, a bicycle pump can be used if desired.

The boiler is designed to carry up to 50 lbs. per sq. inch, and should be tested to 75 lbs. per sq. inch. The boiler is to be supported in the boat by two saddles curved on the upper side to fit the boiler and on the lower side to fit the hull. The various fittings, safety valve pump, etc., will be described in the next issue.

MODERN RUHMKORFF COILS.

The modern American type of Ruhmkorff transfomer, or induction coil, is one of the most important pieces of electrical apparatus to be found in an experimental laboratory. It differs so materially in efficiency from the old fashion types of foreign construction, that to construct a coil along the lines of a decade ago, would be at a considerable waste of time and material in the winding.

The one to six inch spark coils, as constructed by the makers of today, are the result of delicate calculations made in connection with the construction of thousands of coils to be used in "wireless" work, and gas engine operation, each point of detail being perfected by comparative experiment in the mutual relation of one part of the coil to the other.

It is obvious that in these numerous tests, many old-time theories regarding transformation have been eliminated, partly because of proven inaccuracies, and also because commercial competition and the increasing demand for coils to meet certain requirements have brought forth winding machines for bobbins of standard dimensions and specifications securing the greatest efficiency with a miminum of time and labor.

The fundamental principles of the conversion of the electric current are now so well known that an extended description of the simpler forms will not here be given. Old time builders theoretically calculated, disregarding wire resistance and core loss, (hysteresis) an objectionable property which the iron core has, when in action, of resisting the magnetizing current, that the Voltage times Amperage in the primary coil equal V times A in the secondary coil. From this it was deduced that any variation in the number of turns in either winding produced a change in the relation of Volts and Amperes in the primary to that of the secondary coil, all of which is eminently true. But much, however, has been learned by recent work regarding the adjustment of the primary to the work required, the insulation of the windings, and the proper disposition of the secondary bobbins upon the

primary, and the construction of the current break or "interrupter".

This modern research has opened new possibilities, and today the coil makers have no difficulty in constructing sectioned coils to give any desired spark, (20 inches if necessary), wound in perfect layers with suitably prepared insulation between each layer.

Obviously, between contiguous "*turns*" in the secondary coil there is practically no potental difference and little tendency to discharge. With sufficient layers of dielectric substance between each *layer* of wire the chance of injury to the windings is very slight, this insulation being sufficient to withstand any potential which can be derived from the magnetic influnce of the primary coil.

When the secondary is formed of independent sections, which are wound in such directions as to permit of opposite terminals being connected together, the potential near the primary becomes little more than zero; the coil is then able to withstand an enormous strain, and old time difficulties of secondary discharging into the primary are no longer troublesome.

In the construction of secondaries, the amateur becomes puzzled in his calculations, both as to the amount of fine wire to be used to obtain a certain spark, and the proper disposition of this wire in turns upon the primary, for it is the turns which count. Miles of magnet wire indiscreetly placed in the secondary, would oppose the influences of the magnetic field, and not-withstanding how efficiently the rest of the coil might be constructed, the resulting spark would not come up to the expected length and "fatness"; in fact there are in use today, commercially, many coils wound in such a manner that one third of the wire is worthless, or in other words, had this wire been properly adapted to the primary the results would have been one third greater.

In considering a practical coil, we first enter into the theories of a most unique force of nature,—magnetism. We learn that a core of annealed iron wires, of a prescribed length and diameter, has a limit in magnetic saturation, and when that point is reached we may estimate what may be expected from a secondary bobbin properly placed upon the core. For this core, when magnetised, will influence a certain cross-section in a secondary winding, and while the ratio of cross-section of the core to that of the secondary may vary in the plotting of magnetic curves for coils of low and high frequencies, a well accepted rule is to limit the secondary diameter to about twice that of the primary, these calculations being determined by tests made in the construction of many small coils now in general use.

In "filling" and "emptying" a primary winding with electric current by means of a vibrator, or interrupter, we note a certain relation between capacity and frequency. We note that a large secondary containing many turns of wire is often poorly adapted to high frequency, while a smaller one having less turns, sacrifices potential and gains quicker discharge. We are led to appreciate, therefore, that the best interrupter for the amateur's first experiments is one adjustable within reasonable limits, either by weights fastened to the free end of the vibrator, or by varying the length of the vibrator at will.

A condenser (the capacity of which is governed by the frequency and strength of primary battery) is used with this type of interrupter.

Having decided upon the size of the core, and the amount of primary current at one's disposal, one enters into the calculation of the size of wire to be used in the primary. The gauges of wire usually run from No. 14 for large coils to No. 18 for small ones.

As the primary resistance is low, and the number of layers usually two, the most efficient winding for getting the best results out of the core, with a specified frequency of interruption, is easily decided by experiment. The magnetic influence of a primary core may be readily tested with iron fillings, or by suspended needles placed within reach of the lines of force.

Tests have proven that the most vigorous lines of force play near the ends of the primary core, while at the middle the magnetic curve drops close to the core. Hence we are led to distribute the wire of the secondary where the influence is the strongest.

And if the secondary is wound in two separate bobbins, each bobbin being wound to twice the primary diameter;—each bobbin being as long as its diameter and each bobbin placed one-half its length from the end of the primary core, the core being of such a length that the space between the bobbins will equal about one-half the diameter of the secondary bobbin, and with the insulation in all parts of the secondary perfected, as previously noted in this article, the result should be a coil suited to all the experimental needs of the amateur electrician.

It is, therefore, considerable of a question, in view of the facts above stated, whether the amateur of limited experience should attempt the making of a secondary coil, other than of very small size and capacity, and this is especially true if a secondary adapted to his needs can be purchased at little or no increase over the cost of material. As experience is gained, and a study of coil windings and their action becomes desirable, then constructive work with secondary coils can be taken up to good advantage.

Mr. Blaikie declares that if every schoolhouse had a simple running track just around it or in its basement, asphalted like those in some of the later up-to-date schools in New York City, and, if every pupil ran there at a moderate pace for five minutes each day, it would do more for the American lungs and American health than all the other minutes in the day put together now do.

JUNIOR DEPARTMENT

For the Instruction and Information of Younger Readers.

ELEMENTARY MECHANICS.

F. A. COOLIDGE.

II. Friction.

Before proceeding further with the study of machines we must see what influence friction has upon their action, and what means must be employed to make it as small as possible. Friction may be defined as the resistance a moving body meets as it passes over the surface of another body. It is largely due to the roughness of the surfaces in contact, but some of it is due to adhesion. In the study of the levers no mention was made of friction, as it played so little a part in their action; but in the other machines we must know how much of the force employed in moving a body is lost through the rubbing of the surface in contact. Machinery must be made with a view either to make use of friction, or to remove its influence so that as little of the force as possible shall be lost.

For the simple experiments we are to perform we need a spring balance with which to measure every force exerted. One graduated from ½ ounce to 64 ounces can be bought for 35 or 40 cents. As this is to be used for horizontal forces, a rest to hold it should be made from a block 2″ x 3″ x 4″. A hole 1 ¼″ in diameter should be bored through the block lengthwise and the block then sawed lengthwise. After we have smoothed down the sharp edges the rest for our balance will be 4″ long, 2″ wide, 1 ¼″ high, and it will have a trough running lengthwise to hold the spring balance. An sectional view is seen in Fig. 6. Next we will take an inch board 4′ long, 6″ wide and plane it as smooth as possible on one face, leaving the other face rough. We will call this board *A*. A block *B* 3″ x 4″ x 1″ with a strip ¼″ x ¼″ fastened around the edge of one side, and fitted with a screw hook at one end. completes the apparatus needed. See Fig. II.

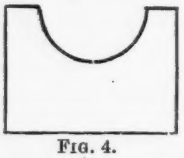


Fig. 4.

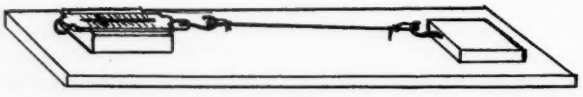


Fig. 5.

EXPERIMENT VI.

Place block *B* upon the rougher surface of board *A* and connect the hook of the block with the hook of the balance by means of a thread. Draw the block along the board several times noticing carefully the force used each time. Do not record the force necessary to start the block, but observe that is is always more than the force required to keep it in motion after it is once started. The average of six or eight trials will give us the force needed to pull the block along the board. Weigh the block carefully and divide the force used by the weight moved. The quotient $F \div W$ is called the coefficient of friction.

EXPERIMENT VII.

Repeat experiment, I using the smooth face of the board. We shall find the force needed to move the block smaller than before. By making the surface in contact as smooth as possible, much of the friction is removed. Calculate as in experiment VI the coefficient of friction, which should be less than .4.

EXPERIMENT VIII.

The block *B* has a base 3″ x 4″ or 12 square inches. One of its sides is 4″ x 1 ¼″ or 5 square inches. Pull the block *B*, resting on its side, along the board *A* and find, as before, the average of six or eight trials. We ought to get the same results as in experiment VII, and should see the truth of the next law of friction, viz., that the size of the surfaces in contact does not determine the amount of friction, although we might expect the friction would be more when the larger faces are touching each other.

EXPERIMENT. IX.

We will now make a series of trials in which block *B* shall carry different weights and exert an increasing pressure upon the board *A*. We can again use the weights made for the experiments in levers, or, if we have not made these, we must provide a number of small tin boxes and by filling them to different depths with sand we can obtain weights that will answer our purpose very well. A careful record of all our experiments, with a statement of the results obtained and inferences made, will make the value of these experiments much greater. Let us arrange the experiment in tabular form.

Weight moved	Force used	F ÷ W =	oefficient of Friction.
8 oz.	2 oz.	2 ÷ 8 =	.25
16 oz.	... ...	.. ..	.....
32 oz.	.....	.....	.....
48 oz.	.....	.....	.....
64 oz.	.....	.....	.....

The figures under force and coefficient are possible figures. In each case the average of several trials

hould be made. In studying the figures obtained it is plainly seen that the force increases almost exactly in proportion to the weight, also that $F \div W$ is the same for the five trials. These verify the laws that friction increases with the weight and that for two given substances the coefficient is the same. That other bodies will have a different coefficient may be seen by repeating experiment VII using a pane of glass instead of board *A*. Another way of reducing friction is the substitution of rolling motion for sliding motion. For this purpose three good, smooth lead pencils may be used under block *B*.

EXPERIMENT X.

Lay the pencils across board *A* with the block *B* resting on them. Compare the force needed to move *B* over these rollers with the force used in making it slide along the board. The force seems ridiculously small. Calculate the coefficient. Can it be a fraction so small? Repeat with other weights and calculate as before.

From the experiments performed we see why so much pains is taken in making a railroad, and we now see how it is possible for a force of eight or ten pounds to move a ton weight. Now we know why the axles and bearings of wagons and machinery are made so smooth, and why oil, grease, and graphite are used so freely. The ball bearings of bicycles and other machines seem to be the height of man's achievments in preventing wasted work.

We must look for a moment at the other side of the question and see mischief would result if there were none. Walking would be impossible. Cars and wagons would not move, or the wheels would turn but no advancement be made. We oil the axles and sand the tracks; we oil the bearings of machinery to prevent and put something on the belt to create friction. In some cases, we need more than we have, and in others we try to remove what we do not need. In conclusion, we must acknowledge friction useful in its place, but worse then useless where we do not need it.

ELECTRICITY BY EXPERIMENT.

I. Magnets.

Faraday, the great electrician, was not satisfied to read of new experiments, but made a practice of working them out for himself, that he might observe everything connected with the processes, and learn from personal observation the phenonena peculiar thereto. The example of this illustratrious man can well be followed, as far as possible, by all who desire to study Electricity and Magnetism, and it will be the purpose of these chapters to so present the subjects by means of simple and characteristic experiments, that anyone may acquire an elementary knowledge which will serve as an excellent foundation for more advanced work.

With this brief statement of our aims, we will consider the subject of *Magnets*. This name is applied to any body which has the property of attracting iron. In the natural form it was known to the ancients, being found at Magnesia, in Asia Minor, hence the name. It is also found in Spain, Sweeden, Arkansas and other parts of the world. In its natural state it is a heavy dark brown or black stone. Its property of attracting iron is best studied by bringing it in contact with iron filings, and this will be our first experiment.

EXPERIMENT 1.

Procure a small quantity of clean iron filings from a machine shop, or make them by filing a piece of cast iron with a coarse file. Lay a piece of *Magnetite*, (magnetic oxide of iron) upon the filings, turning it over so that all sides and the ends will come in contact with the filings. Upon lifting, we observe that the filings are so strongly attracted at the end, that a considerable quantity is retained thereon, but that at the centre no such attractive force seems to exist.

There is another property peculiarity to this stone, which was discovered by the Chinese; if suspended by a string it will turn so as to point north and south hence the name *Lodestone*, or leading stone. In the navigation of ships this was the compass of earlier days.

EXPERIMENT 2.

Suspend a piece of Lodestone by a strand of untwisted silk and observe the tendency to turn as stated,

The natural magnet possesses the property of imparting magnetism to pieces of hard iron (steel,) making of them *artificial magnets*.

EXPERIMENT 3.

Take a piece of steel (large sewing needle or knitting needle) and rub one end from the centre with one end of piece of Lodestone; rub the other end from the centre with the other end of the ore. See if the piece of steel will attract iron filings, and at what points the attractive force is greatest. Suspend at the centre with stirrups made of small copper wire and held by a strand of untwisted silk thread, and see if it will turn and point north and south.

This artificial magnet is a simple form of the mariner's compass, the latter being more strongly magnetized, and suspended in a more sensitive and usable way. The ends of a magnet, (either natural or artificial) are called the *Poles*; that pointing towards the North being generally termed the North pole, and the other the South pole. All magnets will have both poles in some form, the attractive force of the earth acting upon each, being about equal. The reason why the magnet points North and South is that the earth is a great magnet with magnetic poles, which are not the same, however, as the geographical poles. Why the suspended magnet turned will now be learned in

EXPERIMENT 4.

Suspend the bar magnet as in the previous experiment, and note the North seeking end or pole. Holding in the hand a similar bar or horseshoe magnet, bring the N pole, which has been marked to indicate it, near the N pole of the suspended magnet. The N

pole of the latter is repelled by the N pole of the magnet held in the hand; if the other or S pole is held near the N pole of the suspended magnet the two are attracted towards each other. After trying each pole of each magnet, we will learn that;—*Like poles repel, and unlike poles attract each other.* From this we learn that there must be two kinds of magnetism; that which is attracted towards the N magnetic and that which is attracted towards the S magnetic pole. From what we have already learned of the attractive and repelling force of like and unlike poles, it follows that the magnetism of the earth's poles must be of the opposite kind to those of the magnets. The magnetism of the earth's N pole must be S magnetism, the N magnetism being at the South magnetic pole.

It has been already stated that, with the bar magnets used in the preceeding experiments, the earth's magnetic force affected the poles of the magnet equally. The following experiment will show that this is true.

EXPERIMENT 5.

Magnetize a large sewing needle. Place same on a piece of thin cork, along the top of which has been cut a groove for holding the needle in position. Place in the centre of a shallow dish of water. If the needle has been sufficiently magnetized, it will slowly turn and point North and South, but with no tendency to move towards either of these points.

As permanent bar magnets will be necessary to other experiments to follow, the following directions for making a pair are given at this time, that they may be used in experiments. The principles governing the method used will be considered at another time.

Obtain two pieces of tool steel, 4″ long, ½″ wide and ¼″ thick, and smooth all sides and ends with a fine file and emery cloth; wind one the full length with a close coil of magnet wire, about No. 16 guage. Connect the ends of the wire coil with a battery of several dry cells connected in multiple, i. e., the carbon or centre terminals connected to one wire, and the zinc or outer terminals to another wire. Take careful note of which way of the piece of steel is contained in the coil, the way the coil turns around the steel, and the ends of the coil connected to the carbon and zinc terminals of the battery. Allow the current to flow around the coil for a few minutes, lightly tapping the end of the steel with a small hammer. Remove the piece of steel and it will be found strongly magnetized. Test with a suspended bar magnet to determine the polarity of the ends, marking the N pole with a slight scratch across one side near the end. Mark the other piece of steel with a similiar scratch, place in the coil and magnetize so as to have that end the N pole. Reversing the connections with the battery, or the direction of the winding of coil around the piece of steel will reverse the polarity of the magnet.

For storing bar magnets when not in use, make a block of wood long and wide enough to have a dividing strip of wood ½″ wide between the magnets, and at each end a "keeper" made of soft iron. These should always be placed against the poles of the magnets, and will prevent them from loosing the magnetism.

CORRESPONDENCE.

No. 74. CHICAGO, ILL., Feb. 18, 1904.

Being a reader of your paper, "AMATEUR WORK" I would like to ask how a storage battery can be sealed up so as to prevent it from corroding at the connections. I have made and used quite a number and understand them fairly well, but cannot overcome this fault. V. A. S.

The creeping of salts from the electrolyte is a fault common to about all form of batteries. The best method of preventing this is to coat the exposed parts of the elements with melted paraffin. The other way is to adopt a form which will permit of sealing with pitch, but this is a difficult matter to do successfully.

No. 75. CHICAGO, ILL., Feb. 22, 1904.

On Page 99, Amateur Work for Feb. 1904, it reads;—"Lay out a centre line, passing through the centres of the end edges and another at right angles thereto at the centres. Then lay off the three holes for the knife edges so that the upper edge of the holes at the ends just touch the line and the bottom edge of the centre hole does the same". There is a line on the beam in the drawing with the holes touching it but it seems to be about 1-32 inches above the centre of the beam, the 1-16 inches shown appearing to be at the centre. Where are the holes located with reference to the horizontal centre of the beam? Would a line touching the edges of all the knives be in the centre "up and down" of the beam? H. H. B.

The upper side of the holes for the end knife edges, and the lower edge of the hole for the middle knife edge lie on one straight line which is 1-32 inch above the centre line of the beam. In all balances the knife edges must lie in the same plane.

No. 76. ANDERSON, IND. Feb. 22, 1904.

Please send me instructions for finding the amount and size of wire to be used on dynamo the size and shape of the accompaning cut not shown, to produce 110 volts and 4 amperes; f it can be wound for that. If not, the highest E. M. F. possible. J. W. J.

This dynamo cannot be wound for four amperes at 110 volts. It might give two amperes at that pressure, or four amperes at 55 volts. There are not enough slots, even with two coils in each slot, for so high a voltage. For 110 volts there should be at least 20 slots. If that number is used they would be 5-16 inch diameter. Armature should be wound with 20 coils of No. 24 double cotton covered wire, 16 turns per coil, two coils or parts of two coils in each slot. This would require about 300 feet of wire. The field magnet core should be at least 2 inches in diameter instead of 1 3-8 inches. This could be wound with 25 layers of No. 30 single or double coiton covcred wire. This would require about 3000 feet. The pole pieces come too close to each other; 1 inch or 1 1-4 inch would be much better than 1-2 inch as shown in the drawing. Speed, 2000 R. P. M.

No. 77. CHARLESTOWN, MASS. Feb. 20, 1904.

I have a few questions to ask and would be greatly obliged if you will answer them. A. About what would be the cost of two ebonite disks, about 19 inches in diameter and 1-8 inch thick. Where is a good place to buy ebonite? B. Would it be convenient for you to give directions for making a 1-4 H. P. air engine in one of your future numbers? What would be the cost of materials? What is the cost of running a hot air engine as compared with a steam engine? C. What does aluminum cost per pound and where may it be bought? R. C. H.

Two discs of hard black fibre would weigh about three pounds and cost about 50 cents per pound. I think you can obtain them from Chandler & Farquhar Co., 34 Federal St. Boston, Mass.

A hot air engine of about 1-8 H. P. is in this issue. From it you can get a general idea of size and shape for a large one. The author is arranging to supply castings which can be finished to any desired extent, the price of which has not yet been determined. The cost of sheet aluminum depends upon the gauge. It can be purchased of A. J. Wilkinson & Co. 180 Washington St.